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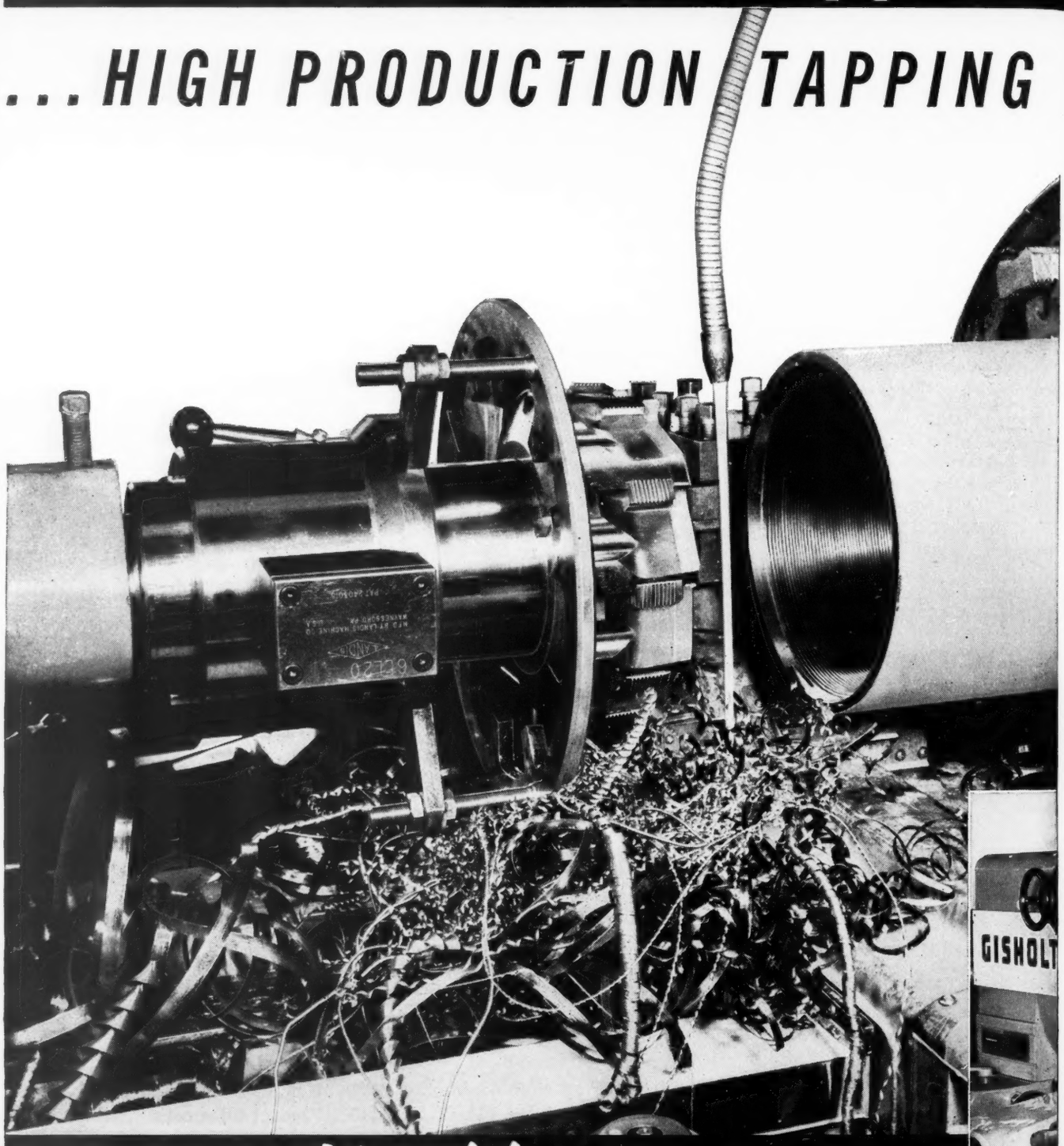
...HIGH PRODUCTION TAPPING



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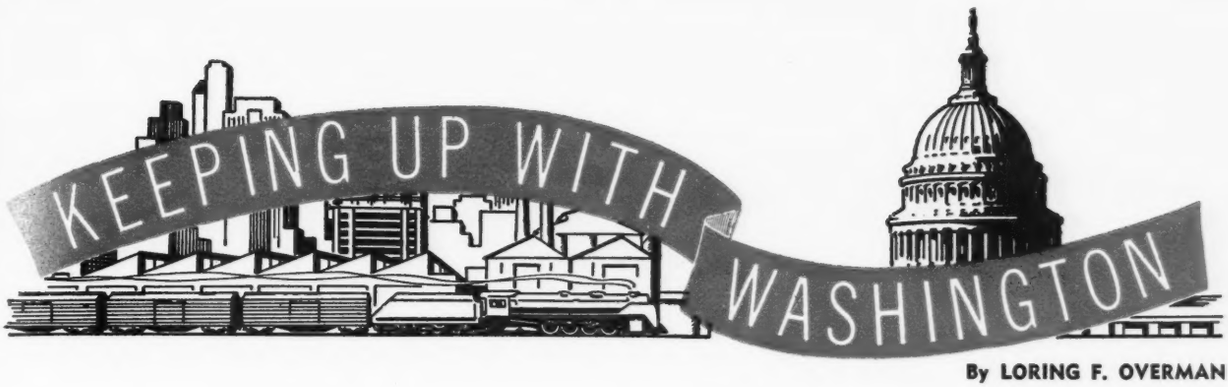

By LORING F. OVERMAN

Machinery Industries Under "Little CMP"

IMPORTANCE of the machine tool and component industries to the defense program was spotlighted in mid-May when the National Production Authority issued two orders that had the effect of setting up a "little CMP plan" to carry those industries over until the regular Controlled Materials Plan takes effect some time after July 1.

The two newly issued orders (M-60 pertaining to components, and M-61 to machine tools) were required, NPA explained, to assure that vital manufacturers would obtain needed steel, copper, and aluminum for July delivery. After that time, the Controlled Materials Plan is slated to schedule production and allocate materials. The interim action represented by the issuance of these two orders will bridge any gap before CMP reaches its full effectiveness.

Under Orders M-60 and M-61, each group is assured not less than 100 per cent of its base period consumption of iron and steel products, with the guarantee rising to as much as 140 per cent for more than a dozen classes of machine tools and related equipment. Priority ratings for 95 to 130 per cent of copper products and for 90 to 125 per cent of aluminum products have also been granted to various classes in the components and machine tool manufacturing groups. The first three months of 1951 have been designated the base period for applying the percentages, and NPA will assist any who have difficulty in locating sources of supply.

Producers of important components have reported increasing difficulties in getting materials, according to Marshall Smith, director, NPA General Industrial Equipment Division. "Raw materials inventories," Mr. Smith said, "have become so depleted that many plants are not able to maintain efficient operations. Yet common components must be produced well in advance of their incorporation into end products. And failure to provide these components in advance would result in serious bottlenecks in the fulfillment of defense requirements.

"In times of national emergency, a rapid build-up of machine tools also is mandatory before attaining accelerated industrial production. The machine tool industry operated at a $200,000,000 production level in 1939, climbed to a peak of $1,320,000,000 in 1942, and tapered off in 1944 as the urgency of the war situation was met. Going into the year 1950, the machine tool picture was back to about the 1939 level.

"In selecting the first three months of 1951 as the base period for both the machine tool and component parts industries, NPA has chosen as nearly normal a quarter as possible. The supply of materials established by NPA orders on that basis is absolutely the minimum required for a balanced production of defense, defense-supporting, and essential civilian goods."

No extension of the "little CMP" priorities to other than the classes of machinery and components named in the orders is contemplated. "The classes and items specified in NPA Orders M-60 and M-61 are those on which all other production must be based," said Mr. Smith. "Virtually all basic production machinery is covered by the newly granted priorities; and no extension to industries other than those named is contemplated."

Order M-60 authorizes the use of a DO-70 rating for various components, such as abrasive products, files, saws, bolts and nuts, welding rods, valves, ball and roller bearings, motors, etc. Order M-61 authorizes a DO-75 rating to procure materials for use in producing machine tools and certain related equipment. Complete copies of both these lists can be obtained from the National Production Authority, U. S. Department of Commerce, Washington, D. C.

Armed with the foregoing orders, manufacturers of the products listed need not be greatly concerned as to whether the Controlled Materials Plan is put into effect on July 1 or later. Present indications are that there will be no delay and that scheduling and allocating will be the rule from the third quarter until the end of the emergency. The National Production Authority is whipping up the horses in an effort to get the plan into operation, for it is again realizing that control of any one segment of the economy calls for other controls. Thus the military and the defense planners will not feel too sure of scheduled production until a definite program is made for the defense share of the economy.

Defense planners preparing for CMP operations have been shocked to find that claimant agencies and industry divisions of NPA, in submitting estimates of requirements beginning with the third quarter, have indicated that their needs for scheduled production will far exceed available supplies of steel, copper, and aluminum. The agencies are presumed to be estimating only defense needs and the most essential civilian requirements. It had been assumed that after the "musts" were scheduled, there would be plenty left for consumer activities to operate in an open-ended CMP operation.

Industry spokesmen—among them Walter S. Tower, president of the American Iron and Steel Institute—have expressed the opinion that the estimates are deceptive. Mr. Tower said that, instead of being absorbed entirely by the mobilization effort, the economy is being strengthened by steel going into freight cars, oil and gas facilities, farm equipment, and other common uses under Government-sponsored programs. He estimated that nearly 90 per cent of the record-breaking steel output in prospect for the third quarter of 1951 will be for uses that are normally regarded as part of the country's civilian economy.

In any event, whether the demand is normal or otherwise, machinery producers stand at the head of the materials line with their "materials checks" M-60 and M-61.

Consolidated Vultee Aircraft Photo

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Engineering Opportunities Beckon New College Entrants

THE insufficient supply of young engineers graduating from colleges this year presents a serious problem. Due to the heavy demands of the national defense program, coupled with the reduced registration of students in recent years, the supply of newly graduated engineers falls far short of requirements. Industrial concerns have been competing on the campus and in classrooms in unprecedented fashion for this year's crop of engineers. It is conservatively estimated that about 4000 companies have sent interviewers to colleges for this purpose. Most graduates need not worry whether they will find jobs but rather which one of a number of offers will present the widest opportunities.

One of the reasons for the insufficient number of graduates was the discouraging future forecast for engineers back in 1949 in a bulletin issued by the Bureau of Labor Statistics. This bulletin stated: "In the next few years, approximately 1949 to 1952, the number of engineering graduates will greatly exceed the demand."

As the result of that erroneous prediction, registration fell off to the extent that while 35,000 men will graduate from engineering courses this year, the annual figure will decline progressively until, according to estimates, it will drop to a low of 12,000 in 1954. The matriculation of freshman engineering students in 1946 reached a high of 91,000 due partly to the fact that many young men were aided by the G.I. Bill of Rights. Last year the number of freshmen dropped to 34,000.

Engineering graduates this year are fortunate in that they are being offered starting salaries commensurate to the wages paid skilled men who have had years of practical shop experience. There are instances where graduates have been offered as much as $450 per month.

It is hardly likely that such a favorable ratio will be maintained when conditions become normal, because obviously the fledgling diploma-holder is not immediately worth as much to a concern as a man whose work earns a profit. But the graduate engineer has an educational foundation on which he can build a successful future. Our high economic plane has been achieved through science and engineering. There will always be big opportunities for good engineers.

Charles O. Herb

EDITOR

This New Controller Says "Hurry Up, Furnace!"

WITH production reaching toward all-time highs, this new P.A.T. 50 Control already is helping many key plants increase the output of their furnaces. Here's why:

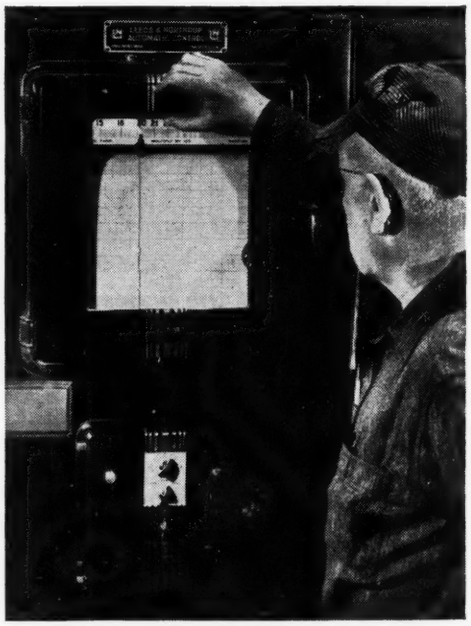
This Control has something that's brand new in proportional, electric controllers. Called "rate action," this feature enables the Controller to act on the *speed* of swings in furnace load, as well as on their size and on the length of time they persist. Thus, if temperature changes gently, it is gently nudged back into line. But if it starts off vigorously—as when the furnace door is opened—P.A.T. 50 reacts vigorously. Then, when the change has been headed off, the Controller starts to back away. But "putting on the brakes" it brings temperature in line smoothly and rapidly.

Thus, "Rate Action" increases production because it reduces the length of time a furnace is off temperature.

Also, Proportioning and Reset Actions are more responsive than before. These two components stop the normal temperature swings which are started by changes in the size and permanence of the furnace load. Even without rate action, these increases would enable P.A.T. 50 to do a better-than-ever job. With rate action, results are superior to any previous electric control.

The News is in the Control Unit at bottom of panel shown at right. Earlier installations can be converted to P.A.T. 50 by replacing the Unit and making slight changes in the Controller.

For details, contact our nearest office, or write us at 4921 Stenton Ave., Philadelphia 44, Pa.



THESE furnaces and controllers are part of the slab-heating equipment with which The Timken Roller Bearing Company, Canton, O., conditions high-alloy steels for rolling. The Timken Company has used many earlier L&N Controllers. They find P.A.T. 50 is a further step forward, not only in guarding quality, but also in increasing production by shortening the off-temperature time.

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The Aircraft Industry Enters a New Era

The aircraft industry has been revitalized. Employment has tripled in plants that were operating on a reduced scale one year ago, and plants that were idle when the Korean War broke out are being reactivated. About eleven and one-quarter billion dollars will be expended this year in building aircraft for the Armed Services, while the budget for new planes in 1952 is over fourteen and one-half billion dollars. Our superbombers and jet fighters represent radical changes over the aircraft of World War II days, which have necessitated the development of new manufacturing methods such as described in the following pages of MACHINERY'S Eleventh Aircraft Production number.

Lockheed's

Lockheed Super Constellation shown in comparison with the present model

AIRCRAFT construction has undergone important changes since World War II. Commercial transport planes and heavy bombers are considerably larger, and the speedy jet fighter planes are being fabricated along sturdier lines than their war-time predecessors. These changes have necessitated wider use of 75S aluminum alloy, stainless steels, and magnesium sheets, all of which are now being employed in heavier gages.

Titanium sheets are being formed into a variety of parts, although this is still being done largely on an experimental basis in the search for a light-weight material of superior strength that will be suitable for use in making airplane components. Many wing parts, such as leading edges, are today milled from aluminum-alloy sheets 5/8 inch thick, with integral ribs and then formed to the required contour on huge stretch presses or pneumatic hammers.

In order to provide ample production facilities to meet the changed fabricating requirements, the Lockheed Aircraft Corporation, Burbank, Calif., started two years ago to erect a "Hall of Giants," which is now nearing completion. Machines and other equipment installed in this department or on order have cost approximately $2,250,000. Some of the huge machines in the "Hall of Giants" will be described in this article.

In addition to the machines illustrated, the aircraft industry's largest stamping press is now undergoing installation. It is an 8000-ton deep-draw hydraulic press with a bed that will measure about 30 by 10 feet. This machine is being built by the Birdsboro Steel Foundry & Machine Co. Another huge machine being installed is a Giddings & Lewis planer type milling machine with a table 34 feet long by 10 feet wide and a bed 74 feet long. This machine will have a weight of approximately 480,000 pounds. It will be employed primarily for the three-dimensional milling of the integral ribs on long aluminum-alloy plate stock.

Difficult forming of high-strength aluminum alloys and sheets of stainless steel can be accomplished readily on the 20-ton Cecostamp shown in Fig. 1, which has a capacity for sheets up to 10 feet long by 8 feet wide. Ordinarily, parts are produced from sheets 0.051 inch thick, but sheets up to 1/4 inch thick are often handled. A Kirksite die and lead punch are generally employed, although both die members are sometimes made

"Hall of Giants"

Changes in the Design and Size of Airplanes have Necessitated the Use of Different Manufacturing Methods from Those Employed in the Past. The New Methods Often Require Machines of a Size Undreamed of in the Airplane Industry During Years Gone by

By
CHARLES O. HERB

of Kirksite. When the die has been correctly positioned on the press bed, dowel-pins are located at certain points opposite the corners of the die and lead is poured around the dowel-pins and up to the die-block to hold the latter securely in place.

The part shown on the machine in Fig. 2 is used as a fillet piece between the wing and fuselage of an airplane. Its approximate dimensions are 60 inches long by 18 inches wide. The greatest depth is about 12 inches. This part is formed from aluminum alloy in four strokes of the Cecostamp. Sheets of rubber are placed on the blank at the beginning of the operation, and these are progressively removed between strokes until the full depth has been obtained. This equipment is also used to bend the leading edge of wings after integral ribs have been formed on flat sheets.

The machine is mounted on a solid concrete "inertia" block, 16 feet high, which floats on springs. No vibration is felt on the surrounding shop floor when blows are struck, even though the impact may be twice that exerted by the conventional drop-hammers used in the aircraft industry.

Heavy skins, armor plate for jet planes, stringers, and circumferentials and longerons of extruded materials can be easily handled by the 200-ton Hufford stretch-wrap forming press shown in Fig. 3. Sheet stock up to 24 feet long by 6 feet wide can be accommodated, as well as extrusions of the same length. All movements of the machine are hydraulically actuated through remote controls located in a pedestal placed well in front of the machine to afford maximum visibility for the operator. Either of two hydraulic cylinders can be actuated to give a maximum pull of 200 tons on the work-piece. The machine is 17 1/2 feet high, and exceeds a gross weight of 325,000 pounds.

This equipment has capacity for forming a half circle, 14 feet in diameter, at full tonnage. Dies or forming blocks up to 23 feet in length

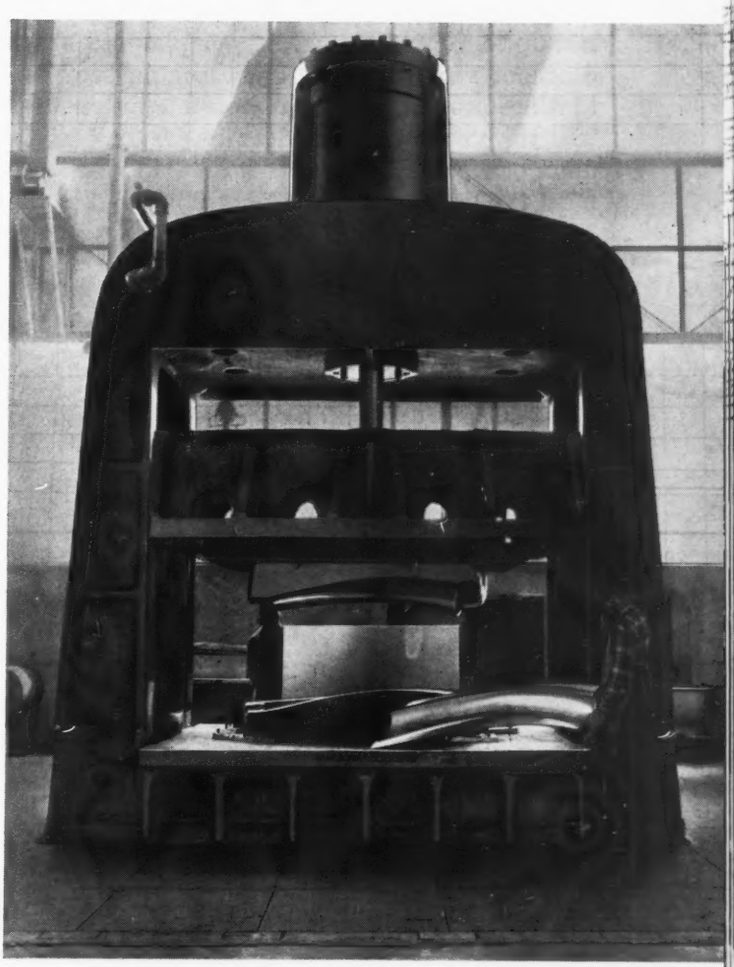


Fig. 1. One of the imposing machines in the Lockheed "Hall of Giants" is a 20-ton Cecostamp used for difficult forming of high-strength aluminum alloys and stainless steel

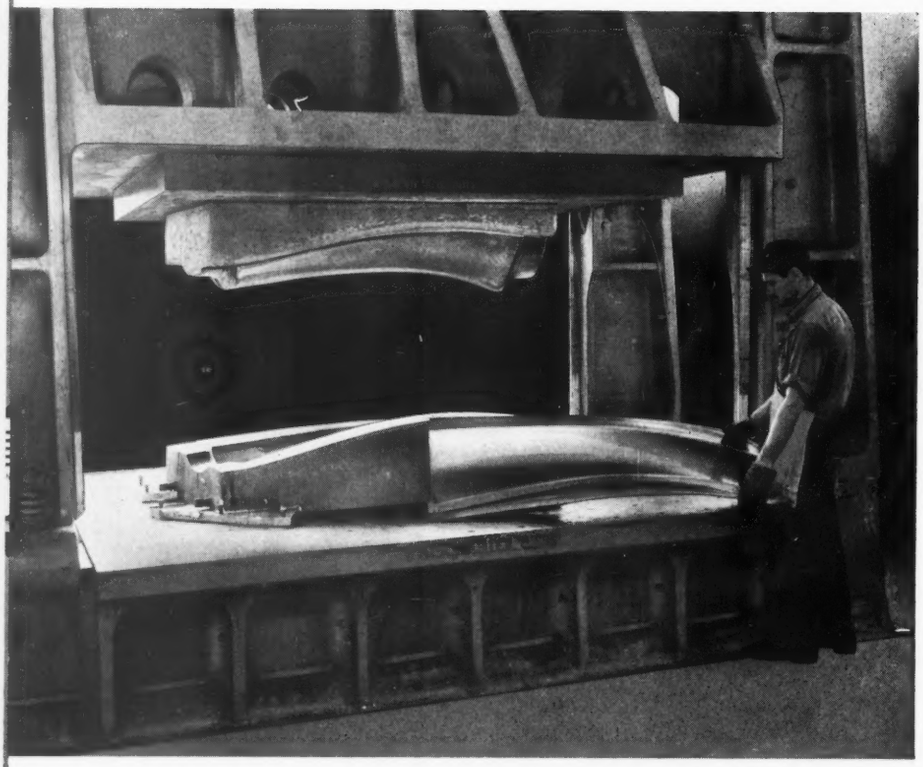
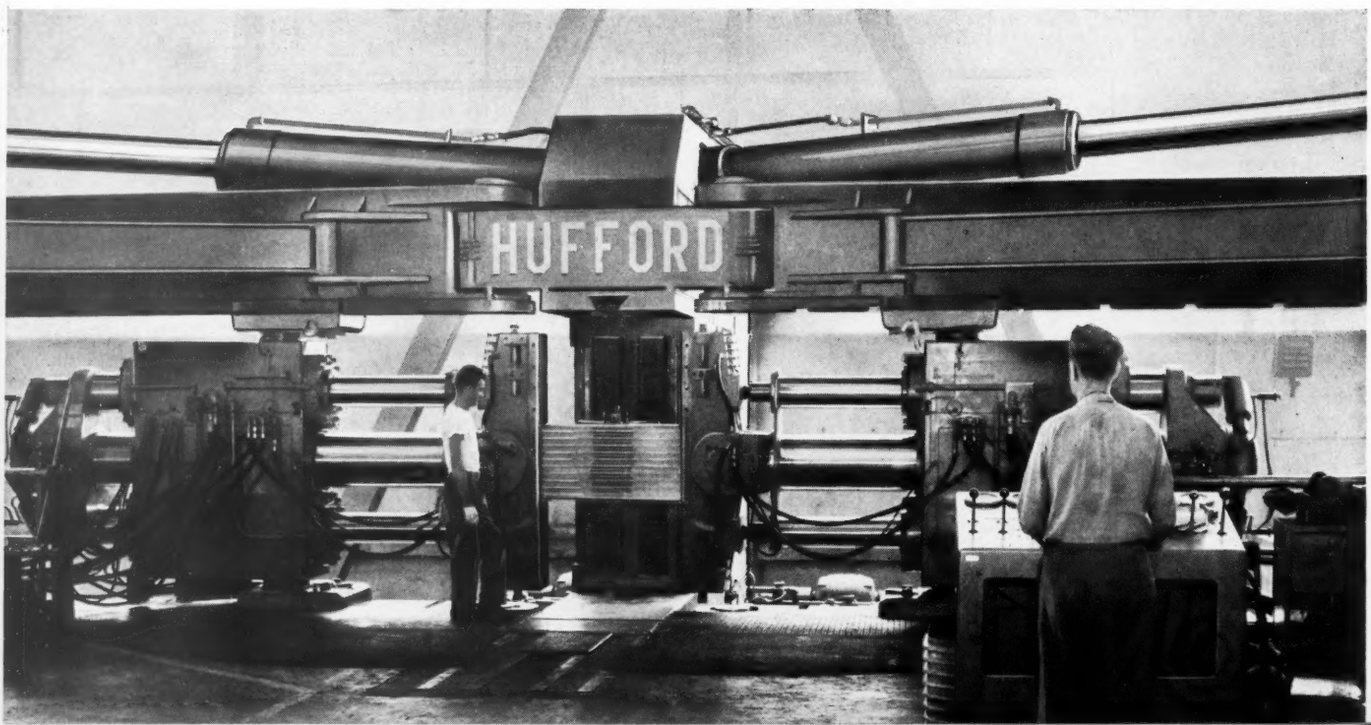


Fig. 2. Close-up view of the large Cecostamp illustrated in Fig. 1, showing a typical part formed in four strokes

can be mounted on the platen through the use of suitable extensions. The sheet jaws open up a distance of 1/2 inch so as to accommodate material up to 3/8 inch thick. In gripping stock that does not require the full jaw width, segments that are not being used can be made inoperative. The jaws are so mounted as to permit longitudinal oscillation, as well as rotation, which permits the work to conform readily to the die. They can also be fixed in position. Jaws for extrusions are attached to the sheet jaws, and all extruded shapes can be accommodated by the use of suitable jaw inserts. Non-symmetrical contours can be handled.

In the operation illustrated in Figs. 4 and 5, an extrusion of duralumin 24S was formed with an applied tension of 24 tons by each jaw. The part was bent to an angle of 52 degrees on each end. In order to prevent wrinkling or tearing of the metal, flexible fillers of a plastic material

Fig. 3. Huge Hufford stretch-wrap forming press which has a capacity of 200 tons, used in bending and forming metal sheets and extrusions



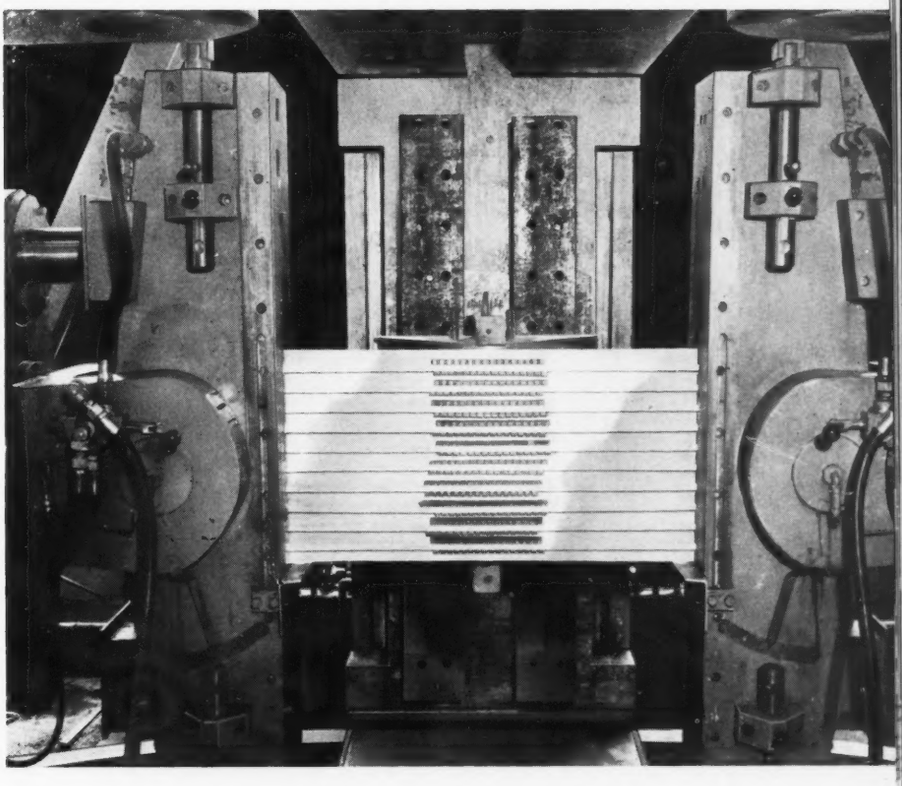


Fig. 4. Comparatively short extrusion as it appears at the beginning of an operation in a Hufford stretch press

were inserted between the ribs of the extrusion. The jaw units, with their ram cylinders, slide on arms that swing at a radius on tracks during an operation, as in conventional Hufford stretch presses.

The big Cincinnati Hydro-Tel illustrated in Fig. 6 is employed for machining structural aircraft members of odd-shaped contour (either from forgings or solid blocks in the case of experimental work), as well as integral ribbed sheets.

The job shown in Fig. 7 is an integral ribbed skin approximately 9 feet long by 6 feet wide. The original thickness of the sheet was 5/8 inch. The material was cut away to a thickness of about 1/8 inch, except on the ribs. An end milling cutter was used in roughing the ribs and removing the excess stock from the remainder of the sheet, while a circular milling cutter with two diametrically opposed tungsten-carbide bits was employed in finish-milling the ribs. Gangs of four cutters are generally used for finishing operations. The cutter movements are, of course, controlled by the overhead tracer unit, which

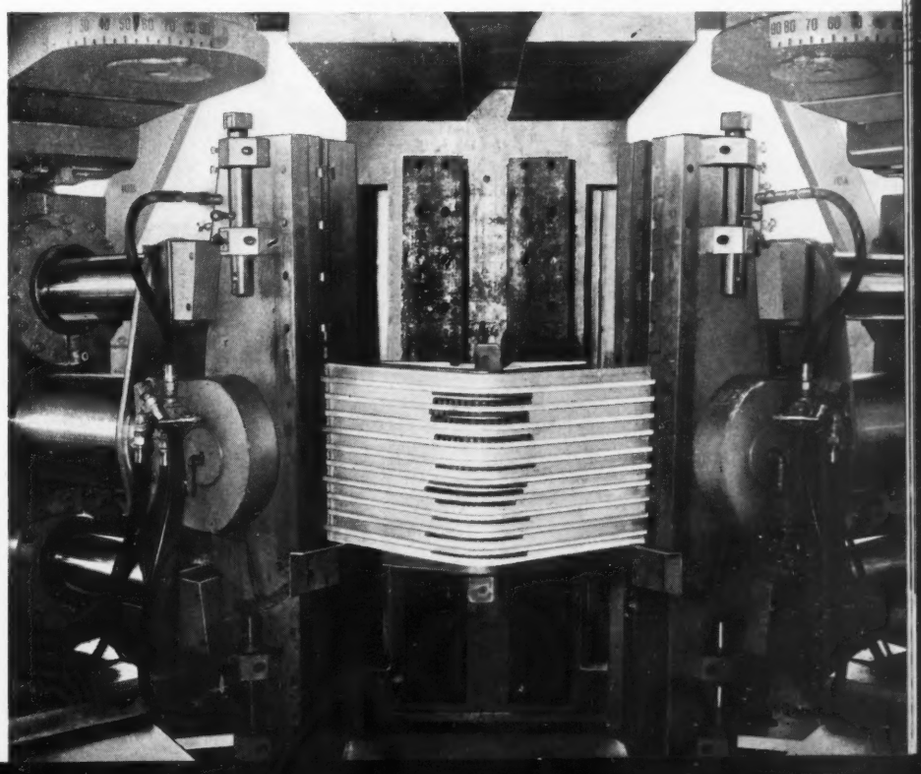


Fig. 5. View of the extrusion in Fig. 4 at the completion of the bending operation, the material having been "wrapped" over the curved block of Kirksite metal

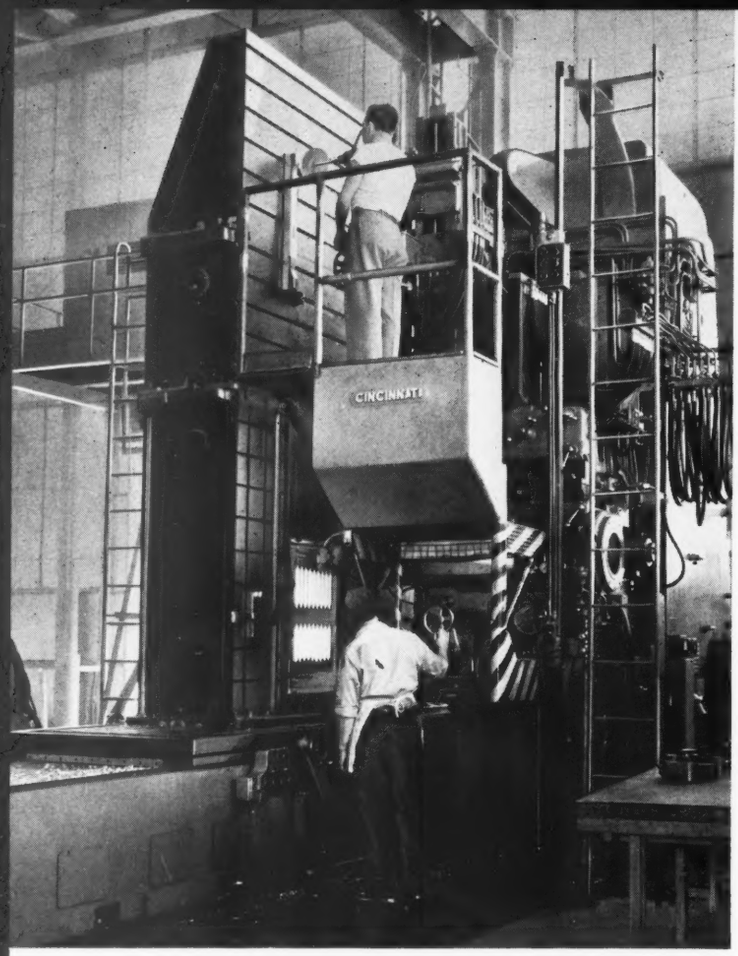


Fig. 6. Huge Hydro-Tel milling machine which is employed for the contour milling of irregular-shaped parts and also for milling the ribs on integral ribbed skins

automatically follows the contour of a master template.

The cutter-spindle of this machine is driven by a 50-H.P. motor at speeds up to 7200 R.P.M. Skins up to 18 feet long by 6 feet wide can be accommodated.

Various parts of irregular contour are handled by the vertical Cincinnati Hydro-Tel shown in Fig. 8. One of the jobs frequently performed is cutting the main landing-gear drag link from billet stock. The particular operation illustrated consists of straddle-milling a fuselage stringer about 12 feet in length. The cutters are moved in and out as the tracer follower moves along the template bar seen at the back of the table.

Contour milling is also performed by a Giddings & Lewis horizontal boring, drilling, and milling machine equipped with a Hydro-Tel tracer unit, as illustrated in Fig. 9. The workpiece shown is an airplane window frame made from magnesium. A face milling cut is being taken around the wide flat surface. Stock is being removed to a depth of 1/8 inch.

A Cincinnati Bickford radial drilling machine equipped with a Bullard Man-Au-Trol spacer is employed for a variety of production jobs. This machine is shown in Fig. 10 set up for cutting holes approximately 3 inches in diameter through curved plates of magnesium about 5/8 inch thick.

In cutting each hole, a 5/16-inch hole is drilled first to serve as a pilot for the fly cutter employed in producing the larger hole. The total tolerance on the diameter of the holes is 0.001 inch, and they are located within $\pm$ 0.002 inch of the specified dimensions. The Man-Au-Trol spacer provides a means of accurately positioning the work

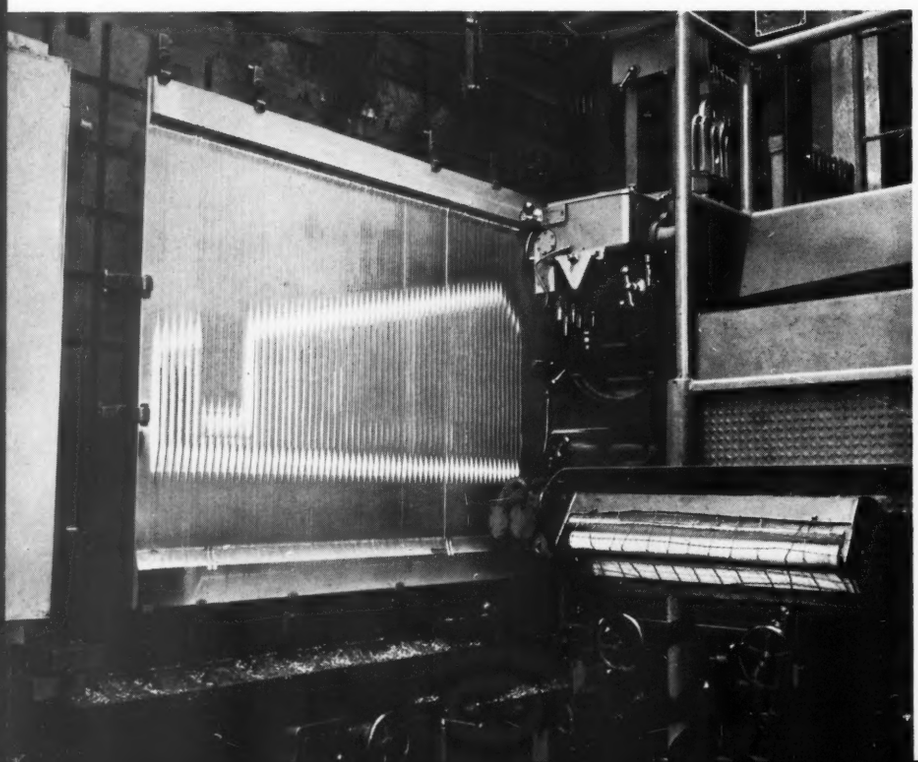


Fig. 7. Typical operation on the large Hydro-Tel seen in Fig. 6, which consists of milling integral ribs on aluminum sheets. The sheets are 5/8 inch thick when they reach the machine, and the sections that are not ribbed are as thin as 1/8 inch following the operation

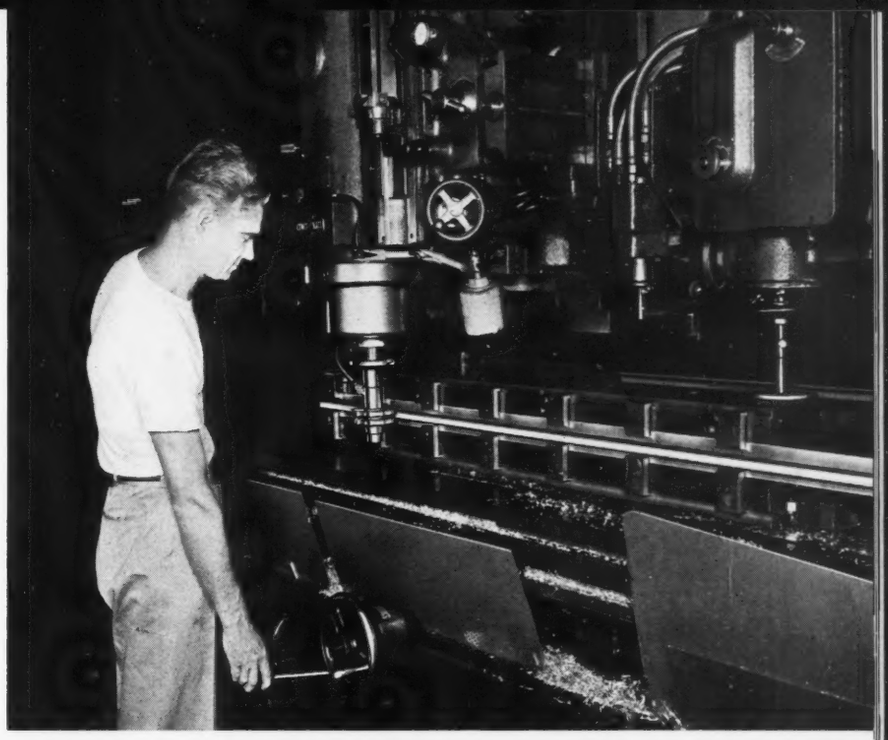


Fig. 8. Vertical-spindle Hydro-Tel milling machine being employed for a straddle-milling operation on a fuselage stringer about 12 feet in length

longitudinally and transversely. The longitudinal and transverse movements are obtained by individual hydraulic cylinders. Thus with ten cylinders available for longitudinal movements and ten cylinders for transverse movements, it is possible to locate work in one hundred different positions by simply setting selector dials. On the particular job shown in the illustration, each hole is bored after the fly cutting operation to insure straightness.

A typical job handled on a large Pratt & Whitney jig boring machine is shown in Fig. 11. This consists of drilling and boring groups of holes in steel plates mounted in various positions

Fig. 9. Various contour milling operations are performed on Giddings & Lewis horizontal boring, drilling, and milling machine here shown, which is equipped with a Hydro-Tel tracer unit

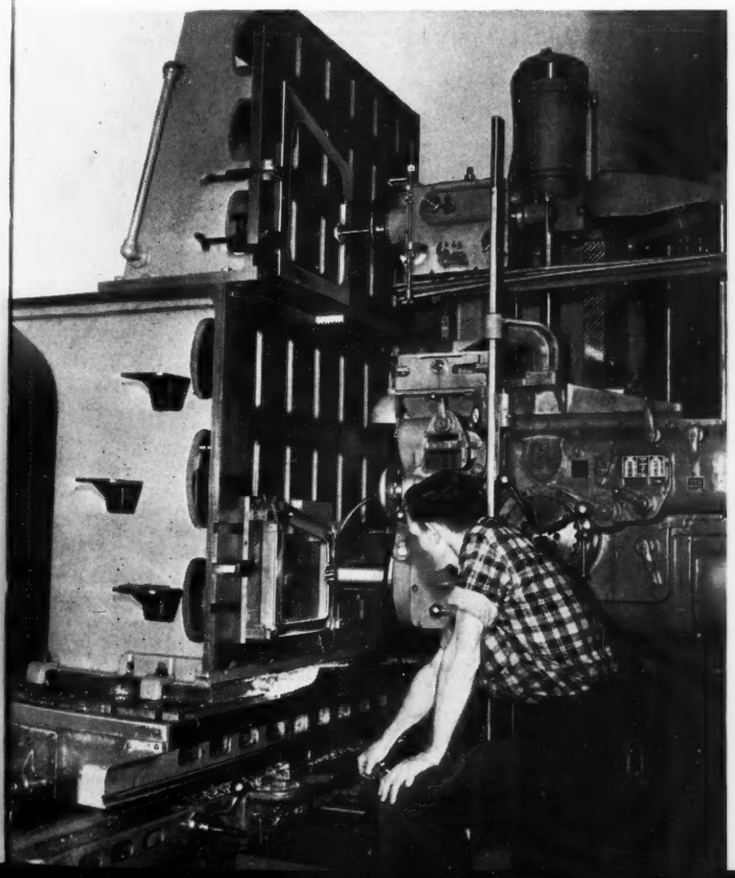
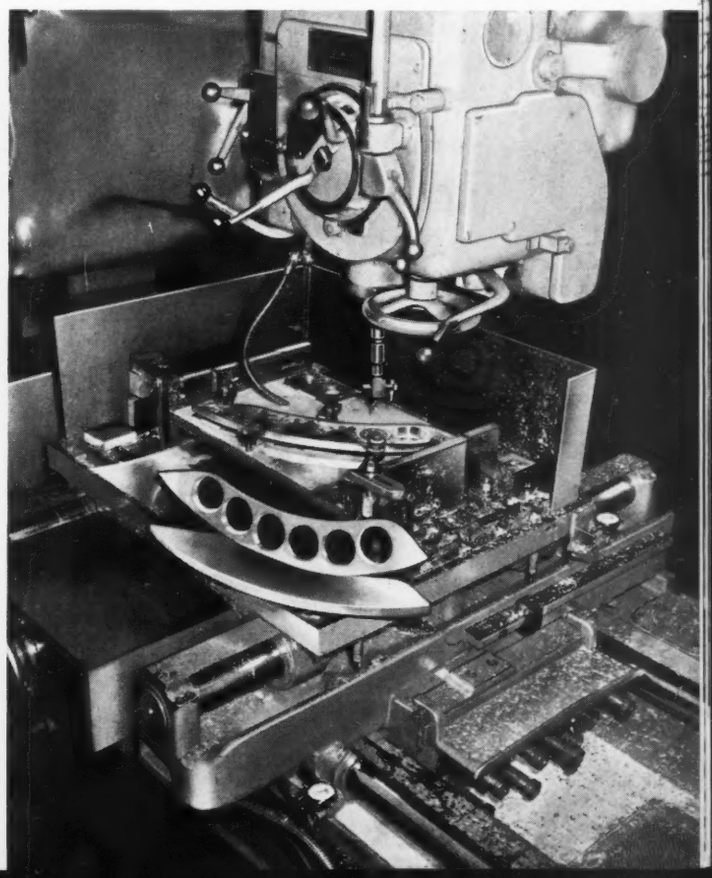


Fig. 10. Typical job performed on a Cincinnati Bickford radial drilling machine equipped with a Bullard Man-Au-Trol for accurate positioning of the work beneath the cutter-spindle



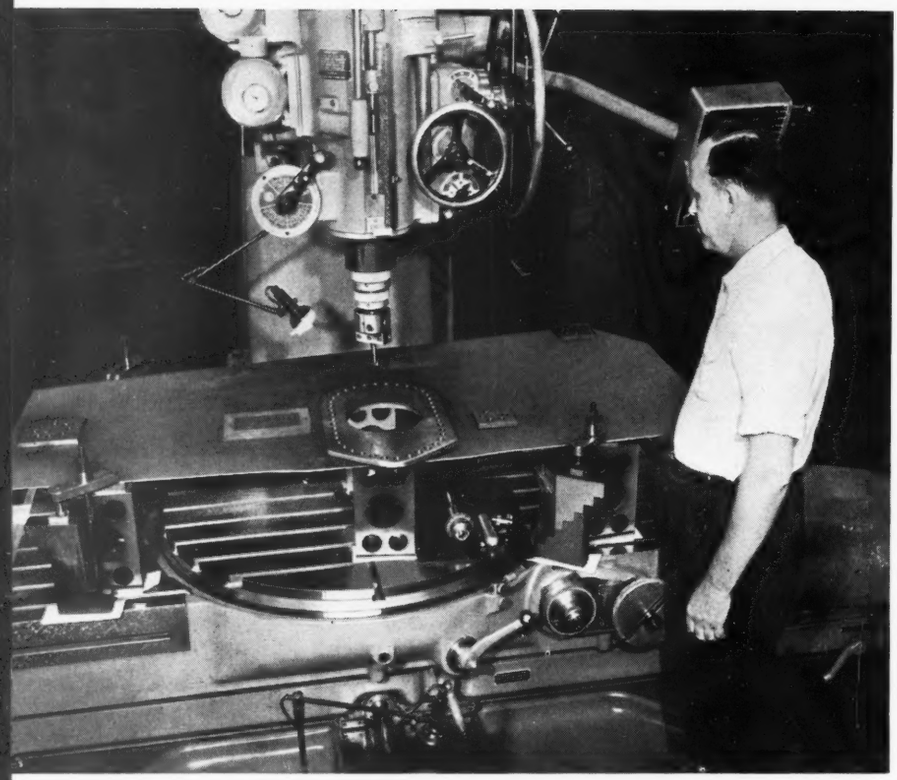


Fig. 11. Employing a huge Pratt & Whitney jig boring machine for taking final cuts on a large master gage that is used to coordinate tooling required in building an airplane

on a steel sheet to provide a master tooling gage. The groups of holes have to be located within 0.0005 inch relative to each other, and the individual holes have to be located within a similar tolerance. However, the machine is frequently employed for work that requires tolerances as close as 0.0002 inch.

Duplicate parts are turned out at high rates of production on a Lodge & Shipley Copymatic tracer controlled dual-purpose lathe. In Fig. 12 this machine is being used for contour-boring parts of the shape seen lying on the front of the tool-slide. The hydraulic tracer unit with a work master is seen at the rear of the machine.

Tubular members up to 5 1/8 inches maximum diameter with a wall thickness of 0.385 inch or tubes with a maximum area of 5.60 square inches can be flash-welded with the huge Taylor-Winfield machine illustrated in Fig. 13. This machine has a maximum capacity of 400 KVA, and can handle work up to 12 feet in length. It is employed principally for welding operations on landing gear members.

In operation, two metal parts of similar cross-

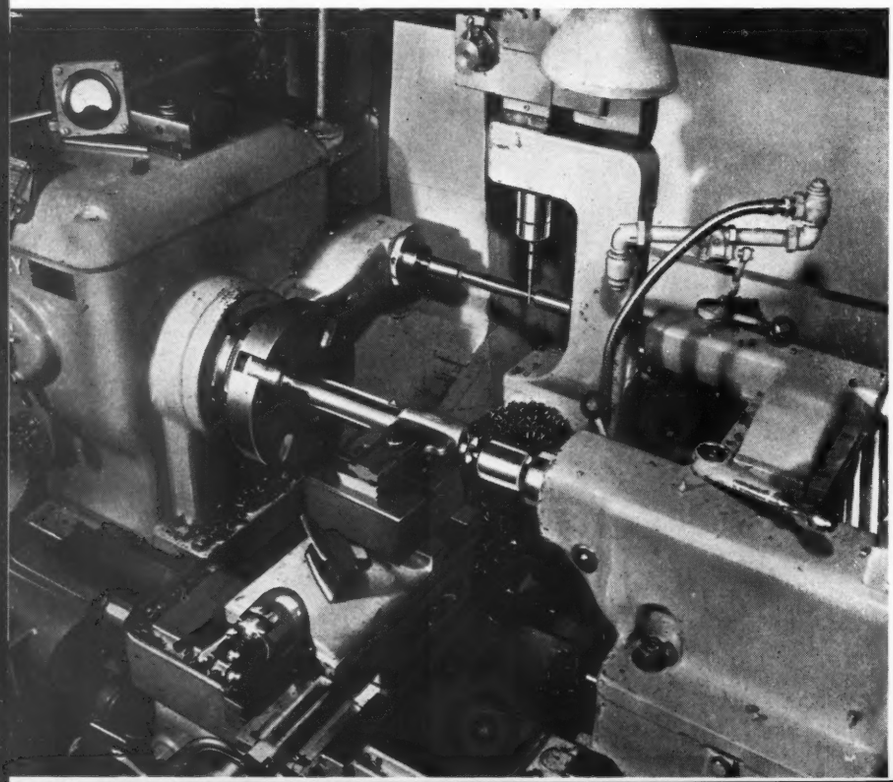


Fig. 12. Copymatic lathe that is used for accurate duplication of various types of aircraft parts, a typical example being seen on the tool-slide

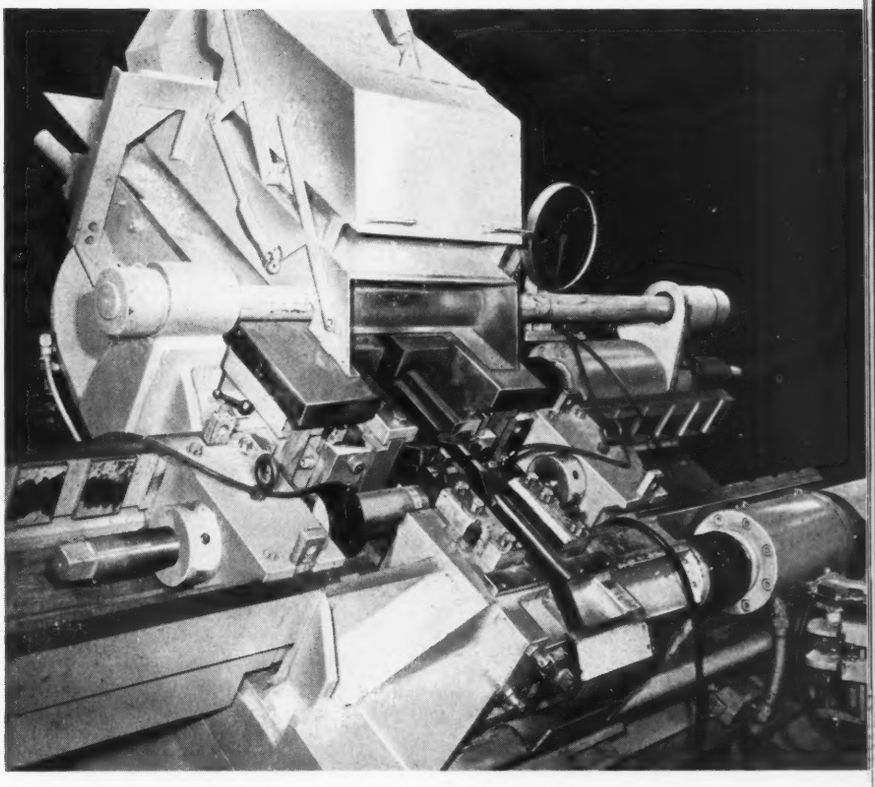


Fig. 13. Large flash-welding machine which is used for joining parts up to 5 1/8 inches in diameter, having a joint area up to 5.60 square inches

section are placed in line with each other and held in that position by copper dies or clamps. The two parts are then brought slowly together, and upon contact, a low-voltage, high-amperage current flows through the parts, rapidly heating the points of contact. The molten metal at the point of contact is expelled, causing a flashing action. During the flashing cycle, the ends of both of the members are heated to the welding temperature. When the proper temperature has been reached, end pressure is applied to complete the welding operation.

Contour Machining

By
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SUPERIOR take-off a[illegible], greater range and economy at m[illegible] high air speeds, versatility of co[illegible] the ability to use negative thrust for la[illegible] maneuvering are important advantages of p[illegible]peller-equipped aircraft powered by gas turbines. One of the United States Navy's newest patrol planes—the XP5Y, built by Convair and provided with four Allison turbo-prop engines and Aeroproducts dual-rotating propellers—set an endurance record of eight hours and six minutes for aircraft powered in this way. Also, the Douglas XA2D Skyshark —a new Navy turbo-prop powered attack plane —is equipped with six-blade, dual-rotating Aeroproducts propellers.

Like the thousands of propeller blades that have been produced by Aeroproducts for reciprocating engines, the blades now used with gas turbines are of hollow steel construction. As seen in Fig. 1, the hollow steel blade is composed of a forged steel thrust member *A* and a formed steel camber sheet *B*, copper-brazed into one light, strong assembly. The machined steel forging *A* forms the thrust face, the blade root or shank *C*, and one or more longitudinal strengthening ribs *D*. The steel forging *A* and th[illegible]amber [illegible]eet *B* are joined by copper-brazing al[illegible] surfaces indicated at *E*.

Unusual machining operations are required to turn out the twisted steel thrust members for these hollow blades on a mass production basis. The thrust members, forged from a molybdenum steel (S A E 4340), are first inspected to see if there is sufficient stock for machining, and then centers are drilled in both ends. With the forging located between centers, the periphery of the shank end is turned. Next, locating slots are milled, and hold-down bolt holes are drilled in the tip end of the blade.

The edges of the forgings are then contour-machined on the Cincinnati duplex Hydromatic milling machine seen in Fig. 2. For this operation, the work is mounted on positioning pads and located between centers in a special swiveling fixture. It is clamped in place by a manually operated, hinged collar that fits around the previously turned shank. Automatic, hydraulic tracer mechanisms control the horizontal movements of the two milling cutters during the longitudinal movement of the table, thus accurately

# of Propeller Blades

duplicating on the edges of the forging the contour of the master profile templates.

Rollers on the ends of the tracer-valve mechanisms contact the templates, which are bolted to the sides of the fixture. As the table, fixture, and work are fed hydraulically past the cutters, the rollers and tracer valves are moved toward or away from the work edges, depending upon the profile of the templates, and the same motions are imparted to the rotating cutters.

During the table travel, the work is revolved by a cam-controlled, air-operated mechanism, so that the edges of the forging opposite the cutters are always in a horizontal plane. The cam controlling this rotation, which is bolted to the bed of the machine, and the air-operated mechanism can be seen in the rear view of the machine, Fig. 3.

The table on which the work-holding fixture is mounted is hydraulically fed at the rate of 5 inches per minute, while the high-speed steel four-fluted milling cutters (2 inches in diameter by 4 inches long) are rotated at 225 R.P.M. Stock removal for the particular size forging shown, which is about 68 inches long by 1 1/2 inches thick by 19 inches wide, varies from 1/4 to 1/2 inch on the leading edge, and from 3/4 to 7/8 inch on the trailing edge. The operation is completed with one pass in about twenty minutes. The over-all width of all size blades is maintained within ± 0.010 inch in this edge milling operation.

Although planers are generally thought to be limited to the manufacture of parts having flat or plane surfaces, such machines have been equipped with automatic, tracer-duplicator controls for the production machining of three-dimensional shapes at this plant. A battery of Cleveland planers has been equipped with Turchan automatic, hydraulic duplicating attachments to machine both the thrust and camber sides on the forged steel thrust members. Two forgings are machined simultaneously in each cycle.

In the first operation, Fig. 4, the thrust sides of the propeller blade forgings are machined. The duplicating attachment, seen at the left, is mounted near the outer end of the horizontal cross-rail on the open-side planer, directly above the master template, which has the same contour as that to be reproduced on the work-pieces. The template is clamped to the reciprocating work-holding table. The two thrust member forgings to be machined rest on positioning pads, and are clamped at both shank and tip ends. Vertical movement of the two tool-holders is controlled by a large hydraulic cylinder (seen mounted on top of the cross-rail), which is supplied with oil in varying amounts through a tracer valve in the duplicating attachment. The amount of oil flowing through the valve is controlled by the tracer roll, which is in contact with the master template. The tool-holders and duplicating attachment are automatically fed laterally after each cutting stroke.

Approximately 11/32 inch of stock is removed

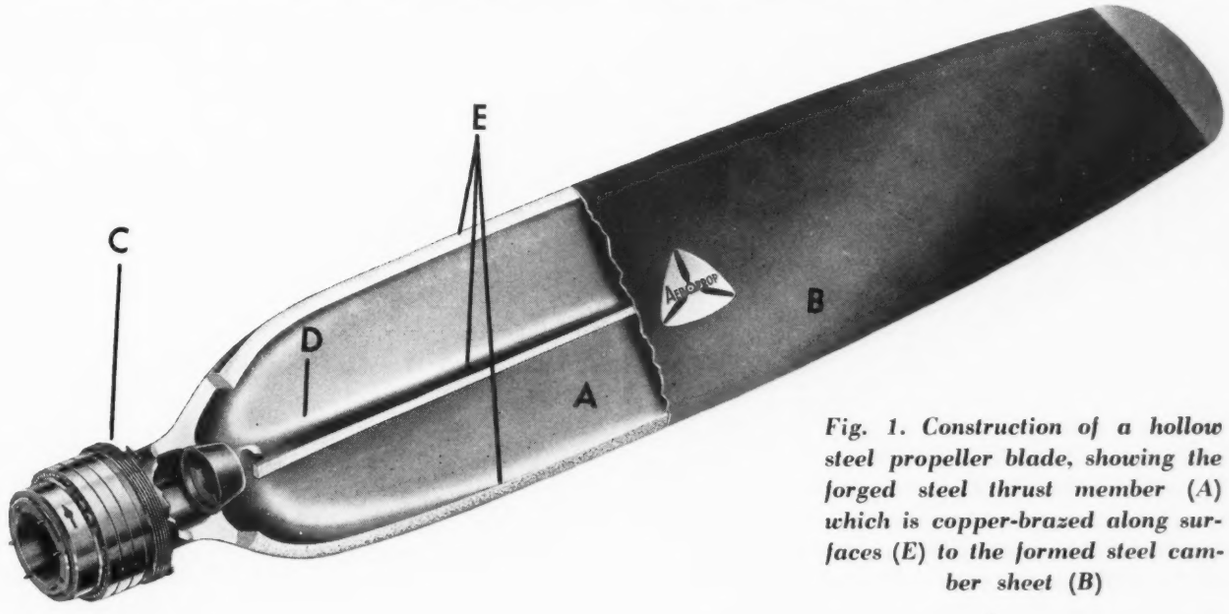


Fig. 1. Construction of a hollow steel propeller blade, showing the forged steel thrust member (A) which is copper-brazed along surfaces (E) to the formed steel camber sheet (B)

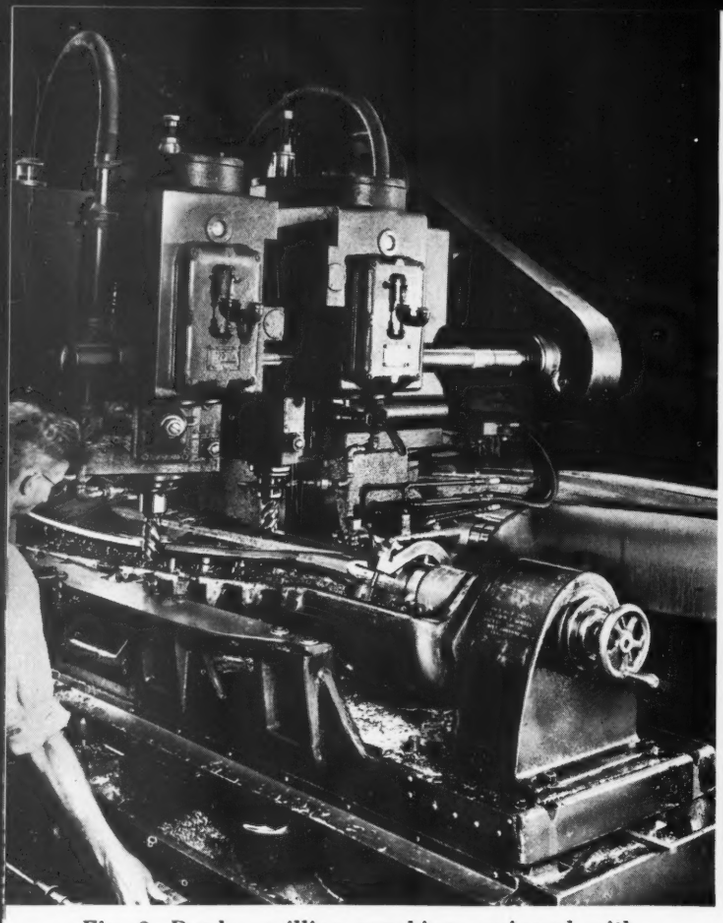


Fig. 2. Duplex milling machine equipped with automatic, hydraulic tracer mechanisms for contour-machining the edges of forged steel propeller blade components

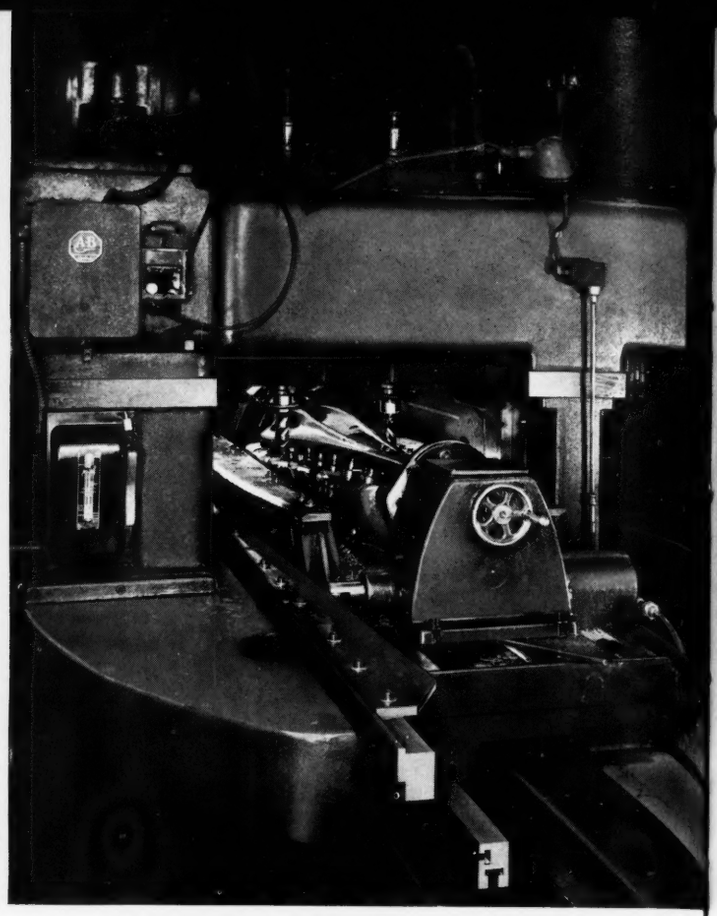


Fig. 3. Rear view of milling machine shown in Fig. 2, showing cam and air-operated mechanism employed to revolve the forging as it is fed past the cutters

Fig. 4. Thrust sides of propeller blade forgings are contour-machined, two at a time, on an open-side planer equipped with an automatic, hydraulic duplicating attachment

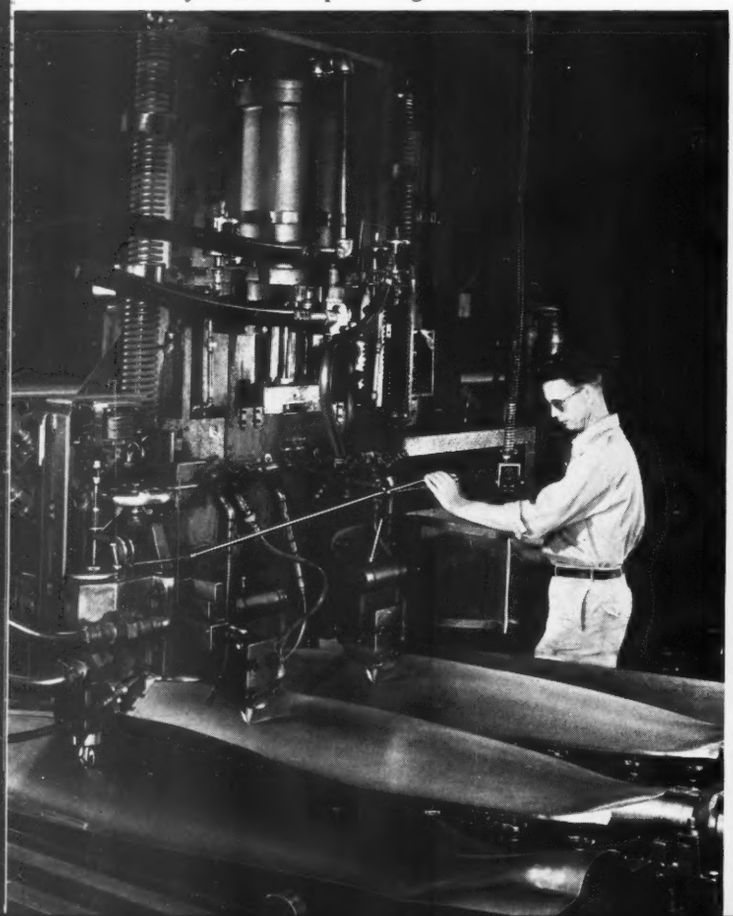
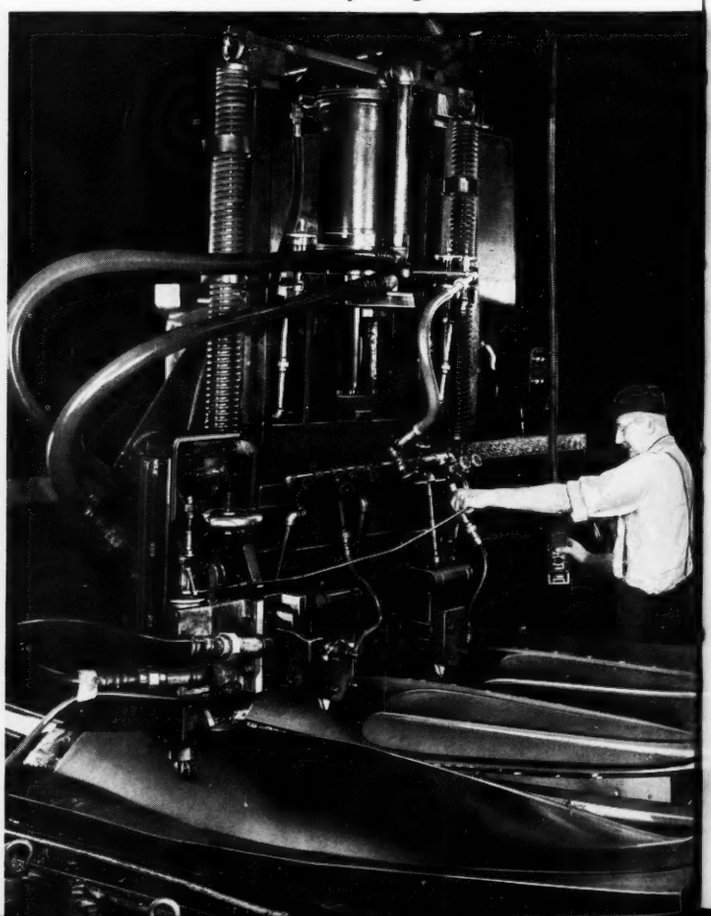


Fig. 5. Camber sides of forged steel thrust members are also machined on a planer. The forgings are gripped on their previously planed thrust sides by magnetic chucks



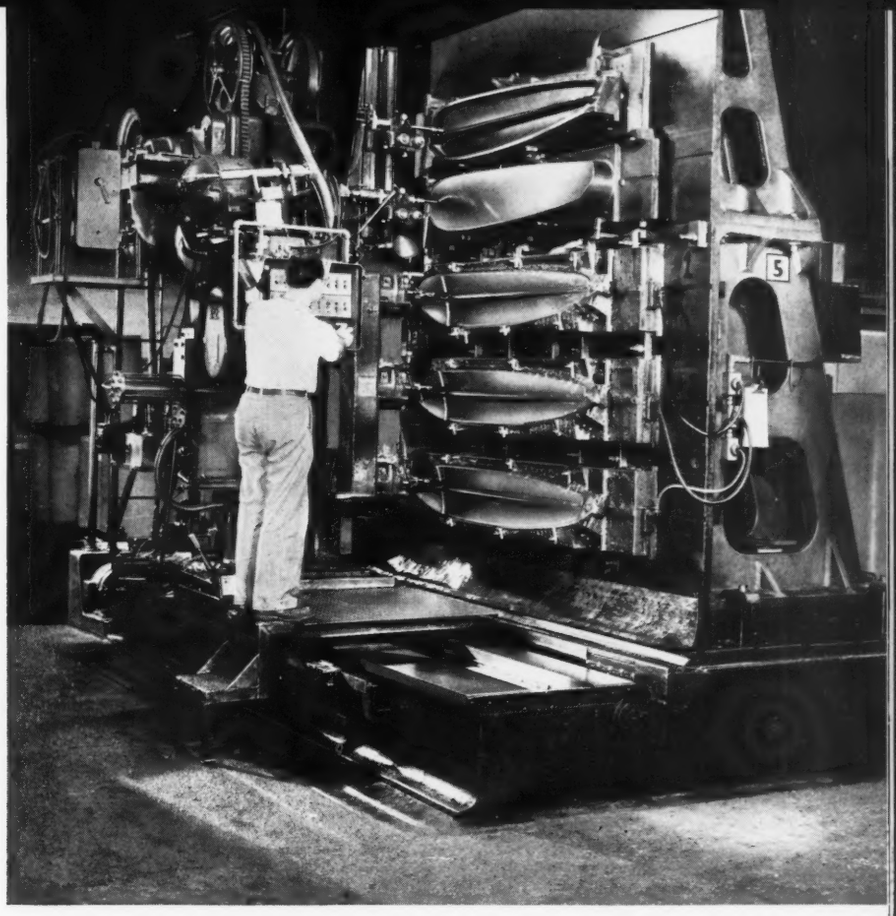


Fig. 6. Cavities on camber side of propeller blade forgings are profiled and contour-machined on tracer-controlled milling machines, three at a time

from the thrust side of the propeller blade forging in three operations, 3/16 and 1/8 inch of stock, respectively, being taken off in two roughing cuts requiring thirty minutes each, and about 0.035 inch of stock in a finishing cut requiring forty-five minutes. All three cuts are made on the same machine. The table travels at the rate of 23 inches per minute during cutting, and has a rapid reverse. About 100 strokes are required for each roughing operation, and 150 for finishing.

A similar set-up, Fig. 5, is employed for machining the camber or ribbed sides of the forged steel thrust members. The major difference in this operation is that the forgings are held on their previously planed thrust sides by means of magnetic chucks.

The cavities between the longitudinal ribs and outer edges on the camber side of the forging are machined on Keller tracer-controlled milling machines (Fig. 6), built by the Pratt & Whitney Division of the Niles-Bement-Pond Co. Forgings for the larger size propeller blades are machined two at a time, while smaller forgings are machined three at a time, as shown in the illustration. While this method of reproducing three-dimensional shapes has been widely employed in tool-room and die shops, its use for accurate and economical quantity production is unusual.

In the set-up shown, two tracers and three cutter-spindles are mounted horizontally on a vertical slide of the machine. A master template is mounted opposite each tracer, and a forged thrust member opposite each cutter. The top tracer and master control the profiles of the cavities being machined—thus preventing the tools from cutting the ribs or outer edges of the forgings—while the lower tracer and master control the contour at the bottom of the cavity to maintain the desired web thickness. The tracers and cutters move in unison, the cutters duplicating the profile and contours of the masters in the work.

Both a rough- and a finish-milling operation are required to complete the cavities in the three forgings. In rough-milling, the helical end-mills are rotated at 360 R.P.M. and fed at the rate of 1.5 to 4 inches per minute, removing from 1/4 to 3/4 inch of stock. About 1/8 inch of stock is removed in finish-milling with a cutter speed of 480 R.P.M. and a feed of 4.5 to 12 inches per minute.

After hand-grinding with portable air tools to remove planer tool marks, the forged thrust member is copper-brazed to the camber sheet, which has been ground flat and pressed to shape in forming dies. The SAE 4340 steel camber sheets vary in thickness from 0.060 to 0.100 inch to suit different sizes of propeller blades. Next the brazed assembly is hardened and drawn, and the shank end of the blade is bored, turned, ground, drilled, and threaded. Finally, the external blade surfaces are zinc-plated and painted to provide corrosion resistance.

B-36 long-range bombers nearing completion in the Fort Worth plant of Consolidated Vultee Aircraft Corporation

RIVETING and welding of stiffeners to airplane skin have been eliminated in fabricating skin sections that cover more than one-quarter of the exterior of B-36 bombers. This has been accomplished through the application of the "Metlbond" process developed by the Consolidated Vultee Aircraft Corporation, in which use is made of a metal adhesive for fastening the stiffeners to the skin.

The process is being applied to clad aluminum alloys and magnesium alloys, and is also applicable to ferrous and other non-ferrous metals and materials. Most of the "Metlbond" assemblies used on the B-36 at present are of magnesium alloy. However, aluminum alloy stiffeners are used on magnesium alloy sheet where design or production improvements result. The combination of materials causes no difficulty.

Many potential applications for metal adhesives exist in airplane construction. However, present uses on the B-36 are confined to thin skins. It has been found that these can be attached to doublers and reinforcing members by the "Metlbond" process with a smooth exterior surface. Any other means of attaching such thin sheet causes surface blemishes at the points of attachment.

A good example of such an application can be seen in Fig. 1, which shows the top (right) and bottom sides of a B-36 assembly. If rivets were used in this case, the smooth panel seen at the right would be covered with rivet heads. Four tack rivets are employed on the ends of each hat section to prevent separation at these points. Excellent resistance to fatigue in areas subject to vibration because of their proximity to pusher propellers is one of the greatest advantages of this construction.

Future applications will undoubtedly include the joining of primary structural members. It is now being proposed that tension shear webs of beams be attached to stiffeners and chord members by "Metlbonding." However, this application must await the testing of such parts to determine the action of the adhesive when subjected to tension and to find the best way of combining it with mechanical attachment at the joints between stiffeners and chord members.

"Metlbonds" B-36 Bomber

By
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The new process should also be of particular interest in the fabrication of integral fuel tanks, because it would permit a reduction in the number of through rivets and bolts. Other applications may include attachments of heavy skins and webs to chord members to avoid reductions in area caused by holes for mechanical attachments and to give smoother exterior surfaces. It may also be practical to build up structural members in this way to avoid taper machining.

While this metal bonding process was first applied in production at the Fort Worth Division of the corporation, the photographs used in illustrating this article were taken at the San Diego plant, where the process is now being widely employed.

Cleaning of the parts is the first step in fabricating "Metlbond" assemblies. Many cleaning processes have proved to give excellent results under laboratory conditions. However, Convair has found that the most practical production method of cleaning consists of the use of solvents. After dyes and paints used for identification purposes have been removed with suitable solvents, clad aluminum alloy parts are cleaned in a vapor degreaser tank, using stabilized trichlorethylene. The only additional cleaning required is to wipe faying surfaces with clean, starch-free cheesecloth in order to remove fingerprints and dirt immediately before application of the adhesive. Dampening of the cloth with a solvent, such as a mixture of 60 per cent toluene and 40 per cent cyclohexanone, has been found to improve the results.

Magnesium alloy parts to be bonded must be subjected to the Convair anodic process known as "Manodizing"; and dried in hot air; then two hours after drying a thin dip-coat of zinc chromate primer (0.0002 to 0.00035 inch thick) is applied. Following dip treatment, the parts must be dried for at least twenty-four hours at room temperature or dried by heating for twenty

Fig. 1. A smooth top surface is obtained on this B-36 assembly by joining the hat section reinforcements to the under side of the sheet with "Metlbond" adhesives

Fig. 2. After thorough cleaning, one or two thin coats of cement are sprayed on the parts. About five minutes is allowed between coats for drying

to thirty minutes at a temperature of 165 degrees F.

No further cleaning is required except that fingerprints, anodic powder, and other foreign substances are removed immediately prior to spraying with cement by wiping all faying surfaces with a clean, starch-free cheesecloth dampened with low-flash naphtha. A low-aromatic naphtha is used because the thin coat of primer previously applied to magnesium alloy parts must not be softened excessively.

When the parts have been thoroughly cleaned, the solvent is allowed to dry for a few minutes, after which one or two thin coats of cement are sprayed on all surfaces to be bonded, as shown in Fig. 2. This cement fills small irregularities resulting from imperfectly machined parts or imperfect tools. At least five minutes is allowed for drying between coats. After the final coat has been applied, the cement is allowed to dry in the air for a minimum of twenty minutes and a maximum of eight hours. Parts are marked with the time, and if the eight-hour limit is exceeded, it is necessary to strip to the bare metal and reprocess completely.

A dry film (tape) is then laid smoothly on one of the mating surfaces to be bonded, as shown in Fig. 3. The stiffening members are placed in

Fig. 3. "Metlbond" tape being applied to mating surfaces of hat sections used in B-36 assembly. The girl who handles the parts wears gloves to keep hand moisture from getting on tape

Fig. 4. Stiffening members are placed in a locating fixture provided with pins and blocks. After applying more tape, the hat sections are positioned on the panel assembly seen at the left

a fixture provided with locating pins and blocks for each assembly. Fig. 4 shows such a locating fixture with some of the stiffeners in place and "Metlbond" film being applied. The skin and doubler assembly is on the table beside the fixture.

If only a few parts of an assembly are to be produced, a fixture is not required. In such cases, the parts may be placed together in the proper relationship and tacked at the corners by applying heat with a soldering iron having a tip of the proper shape.

The combination of the two adhesives (the cement and the dry film) in separate layers produces a bond with good shear strength and flexibility. It is because of this combination that low bonding pressures can be used. These adhesives can be purchased under the trade name "M3C" from Narmco, Inc., of Costa Mesa, Calif., or under the trade name "Silabond A" from Pacific Laminates, of Costa Mesa, Calif. A dry film form (tape) of these adhesives is also available from these firms.

When applied, the film or tape should be sufficiently "tacky" to adhere to faying surfaces. It is normally stored in an atmosphere containing some toluene vapor, which keeps it in the most desirable condition for application. However, if it is too dry, it may be reactivated by wiping with a clean, starch-free cheesecloth dampened with toluene. An alternate method of reactivation is to store the loose film in toluene vapor for a few hours.

Accurate fitting at corners, splices, etc., is not required, as double thicknesses of the tape can be applied at such points without materially affecting the strength. Tape containing the "Metlbond" film has either a nylon or "Fiberglas" cloth base, and can be torn into strips of the desired width or cut into the shape required.

Assembled parts must be cured within seventy-two hours after the cement has been applied, and must be protected by paper covering from contamination and shop dust until time for curing. The assemblies are clamped together

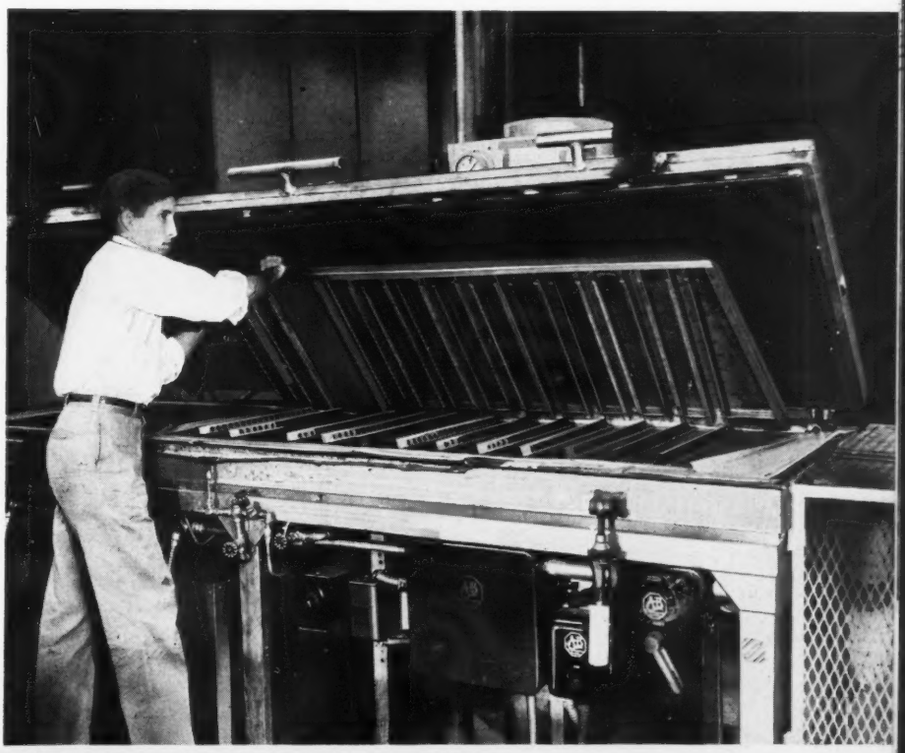


Fig. 5. Fixture that is heated by the circulation of a hot fluid to cure "Metlbond" assemblies. A pressure differential is maintained across thin sheets to hold them flat

over the entire area to be bonded with a force of 7.5 to 100 pounds per square inch.

Curing of flat parts is normally performed in the type of fixture shown in Fig. 5, which was especially developed by Convair to eliminate the necessity for larger and less flexible ovens. In fabricating parts with thin skins, it has been found necessary to maintain a pressure differential across the skin to hold it flat. Therefore, a hollow surface plate is provided below the assembly being cured. A partial vacuum, equal to approximately 25 to 28 inches of mercury, is normally maintained on the bottom surfaces to hold the sheet against the surface plate. The skin can be sealed around its edges with cloth- or paper-backed adhesive tape, or other means.

A partial vacuum of approximately 12 to 16 inches of mercury is also applied under a synthetic rubber blanket that has been placed on top of the work and sealed previously along its edges. The difference between these two pressures holds the thin sheet flat during the curing operation. As a result of the vacuum under the blanket, partial atmospheric pressure is applied to the joints through the locating fixture blocks. The pressures are controlled while the heat is being applied.

This type of curing fixture is heated by the circulation of a hot fluid known as "Ucon," which is made by the Union Carbide and Carbon Co. Since the fixture is held continuously at curing temperatures, the length of time required for the joint line to come to the curing temperature is small. When efficient methods of handling parts and equipment are available, curing cycles can be cut to as little as thirty minutes.

Curing can also be performed in a hot air oven with the type of equipment seen in Figs. 6 and 7. After the parts are assembled, they are placed on a baking table and covered with a rubber blanket. Partial evacuation of the air under the blanket is then accomplished, and the table is moved into the oven. A complete cure is obtained by subjecting the joint line to a temperature of 320 to 350 degrees F. for a period of twenty-five to thirty-five minutes.

Oven curing is particularly adapted for irregular-shaped parts and for parts to which pressure is applied mechanically. When oven curing is used, sufficient time must be allowed for the fixtures to come to the curing temperature. Ordinarily, the total time required for a complete cure is at least one and one-half hours.

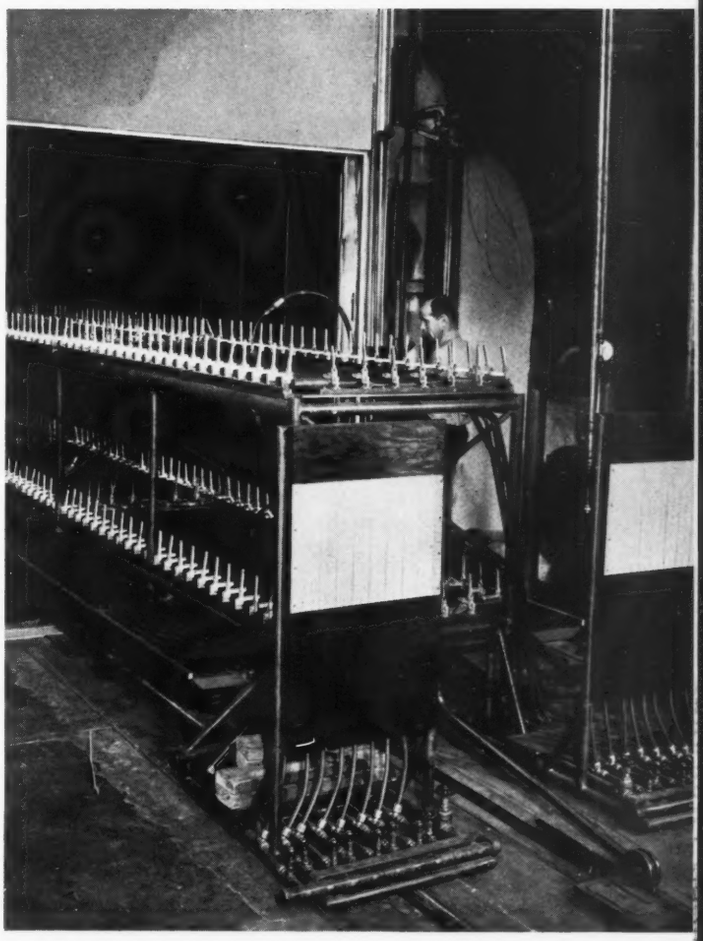
The best vacuum blankets are made by using a heavy "Fiberglas" cloth impregnated and coated on both surfaces with silicone rubber. If adhesive tape is used for air seals, there may be some difficulty with transfer of the adhesive mass to parts and tools when it is removed after cure. Cloth-backed tape has been found to overcome this difficulty, but it is more expensive than ordinary paper-backed tape.

After completion of the curing process, the parts are removed from the jig. Care is necessary in handling at this stage because, at the elevated temperatures used, magnesium alloy is somewhat susceptible to deformation. Also, since "Metlbond" joints have somewhat lower strength near the curing temperature than at room temperature, bonds can be damaged if assemblies are handled with excessive roughness.

As an alternate to the method of curing described, parts may be held together by a force of 7.5 to 100 pounds per square inch for joints containing magnesium, and 25 to 100 pounds per square inch for joints of aluminum alloy. While

Fig. 6. Cleaned, sprayed, and taped assemblies are placed on the baking table and covered with rubber blankets. Air is partially evacuated from beneath the blankets

Fig. 7. Baking tables containing the blanketed assemblies are placed in the oven for about one and one-half hours. The coated joint faces reach a temperature of from 320 to 350 degrees F.



the parts are thus held together, the bonds are partially cured by maintaining the joint line at a temperature of 335 to 350 degrees F. for a period of from five to ten minutes.

Assemblies are then placed in an oven without pressure at a temperature of 320 to 350 degrees F. for a period of twenty-five to thirty-five minutes. Parts bonded by this method must be sufficiently well fitted prior to assembly so that there is no strain on the joint line during the final cure without pressure.

Complete assemblies containing magnesium alloy are next sent to the finish department, where one-dip coat of zinc chromate primer is applied for corrosion protection. When closed stiffeners are used, large drain holes are provided to permit both the interior and the exterior surfaces to be coated with this primer. This operation is not required for parts containing clad aluminum alloy only.

Additional corrosion protection of "Metlbonded" joints is necessary in some cases. The cement normally extends beyond the joint sufficiently to form an external bead. If this bead is removed by trimming of the edges at assembly, they are protected by an extra coat of zinc-chromate primer.

Completed parts are next sent to sub-assembly, where they are attached to the structure by conventional means, such as riveting or bolting. Workers have found "Metlbonded" assemblies easy to install, as they are normally simple in shape and doublers are always provided at attachment points. Thickness is thus sufficient for a smooth riveting job.

Samples of cement films in use are selected for shear tests every twenty-four hours. "Metlbond" film must be capable of developing a shear stress of at least 2500 pounds per square inch in bonds to bare 0.064 inch thick, clad 24S-T aluminum alloy standard panels, with 1/2 inch overlap. A typical value is approximately 3000 pounds per square inch. Ultimate design shear stresses in joints between primed magnesium alloy parts or between primed magnesium alloy and clad aluminum alloy parts must not exceed 500 pounds per square inch.

Comparative studies of "Metlbonding" versus riveting of certain assemblies to which either method is applicable have shown an average man-hour saving of 0.43 hour per square foot in favor of bonding. Additional material costs, however, largely offset this saving. Thus, relative costs of the two methods must be calculated for each specific assembly, taking into account the material to be used, the number of rivets per assembly, and the contact area of the bond. A slight saving of approximately $500 per plane is calculated in favor of "Metlbond" on the B-36. However, other advantages of design and performance incident to this method far outweigh any direct cost benefits.

Producing Jet-Engine

Pratt & Whitney Compressor Blades

By GEORGE H. DeGROAT

CONTINUAL improvement in the jet engines that power our military aircraft have made necessary constant experimentation with different compressor blade designs. The production of experimental blades, ordinarily requiring months, is now accomplished in a matter of days at the Pratt & Whitney Aircraft Division of the United Aircraft Corporation, East Hartford, Conn., as the result of newly developed equipment and the application of unusual methods.

The difficulty in producing such parts as turbine buckets and compressor blades is largely due to their airfoil shape, which varies in cross-section at different locations, or stages, along the axis. More than two thousand such blades were required for a single experimental engine, the performance of which was determined largely by the efficiency of design of the blades and the precision with which they were manufactured.

A new method of producing blade masters employed as three-dimensional templates in making compressor blades is in use at this plant. Four to six months were formerly required for making such masters, whereas by the new method the time has been reduced to three working days. In this operation, an electronic contour follower, Fig. 1, developed by the General Electric Co. in cooperation with Pratt & Whitney Aircraft, is employed to actuate the compound table of a special Moore jig borer, on which a block of tool steel is mounted. The table movement carries the work around the spindle of the jig borer in such a way that the airfoil contour required at any given stage is milled into the block by the cutter in the spindle. The number of cross-sectional cuts required is determined by the length and amount of twist desired in the blade.

In the first step of this operation, the airfoil contour required at the first stage is carefully laid out to an enlarged scale—up to fifty times the actual size of the blade—on a zinc-coated sheet-metal plate. A chord of 24 inches, measured from one end of the airfoil to the other, is used on these lay-outs, and is scaled down to actual blade size with almost stepless reduction, since there are sufficient gears in the jig-borer transmission to control the reduction within an average of 0.0003 inch.

The plate is held on the center column of the contour follower machine by means of several electromagnetic chucks. Reflected light from the etched surface representing the airfoil contour enters the lens of a photo-electric cell, providing an electron emission from the cathode to the anode and thus constituting a current which is amplified to operate two reversible motors. The motors drive lead-screws in the table on which the cell is mounted, so that the electric eye is able to follow the path of the airfoil contour. In following the path of this contour, the center of the electric eye actually represents the tangent point of the cutter at the work. One of the principal features of this device is its ability to trace a closed circuit completely, necessitating the reversal of the field twice,

The photo-electric cell, Fig. 3, is adjustably mounted on an arm that operates two generator selsyns which transmit current to two receivers. The receivers are connected to motors which drive the lateral and longitudinal lead-screws of the jig borer. The distance from the center of the electric eye, in alignment with the airfoil line, to a point on the arm from which the generators obtain excitation is equal to the radius of the cutter multiplied by the amount of reduction. A reversible rotating motor, driven by the two motors previously mentioned, keeps the arm normal to the curve of the path followed by the cell, Fig. 2, with the result that the driving point on the arm generates exactly the same curve as is followed by the photo-electric cell.

An interesting point in this connection is the need for making the blade master heavier than the true airfoil form of the compressor blade, especially at the thin trailing edge, since considerable rigidity is required in the template. This is accomplished by using a cutter in the jig borer that has a radius smaller than the basic radius used in calculating the distance from the center of the electric eye to the driving point on the arm. The amount the cutter is made under

Fig. 1. Jig boring machine and electronic contour follower employed in producing jet-engine compressor blade masters

size depends upon how much excess stock is desired around the contour of the template. Compensation is made for the over-size master by a means to be described later.

The Moore Special Tool Co. equipped this jig borer with saddle supports, anti-backlash lead-screw follower nuts, and special lead-screws that are accurate to within 0.0007 inch in both directions, including backlash, to provide a high degree of accuracy in the reproduction of the airfoil contours. This, together with the use of selsyns, which provide extremely accurate transmission of movement, and other features of the contour follower and jig borer combination permit the production of master blades having contours within plus or minus 0.001 inch from any point on the nominal curve without waviness. After two machining cuts at each stage—one roughing and one finishing—the stock remaining between the stages is quickly removed, and simple hand finishing operations are employed to blend the form.

In operation, the blade master is mounted in a four-spindle Cincinnati Hydro-Tel, as shown in Fig. 4. The follower used in this machine to actuate the spindles has a radius smaller than the radius of the cutters by an amount equal to the excess stock left on the contour of the blade master. This compensates for the difference in size between the over-size master and the true size of the airfoil contour, and insures that

Fig. 2. The photo-electric cell in the electronic contour follower is mounted on an arm that follows the curve of the blade pattern and transmits the motion to the table of the jig borer, thus duplicating the contour in the work

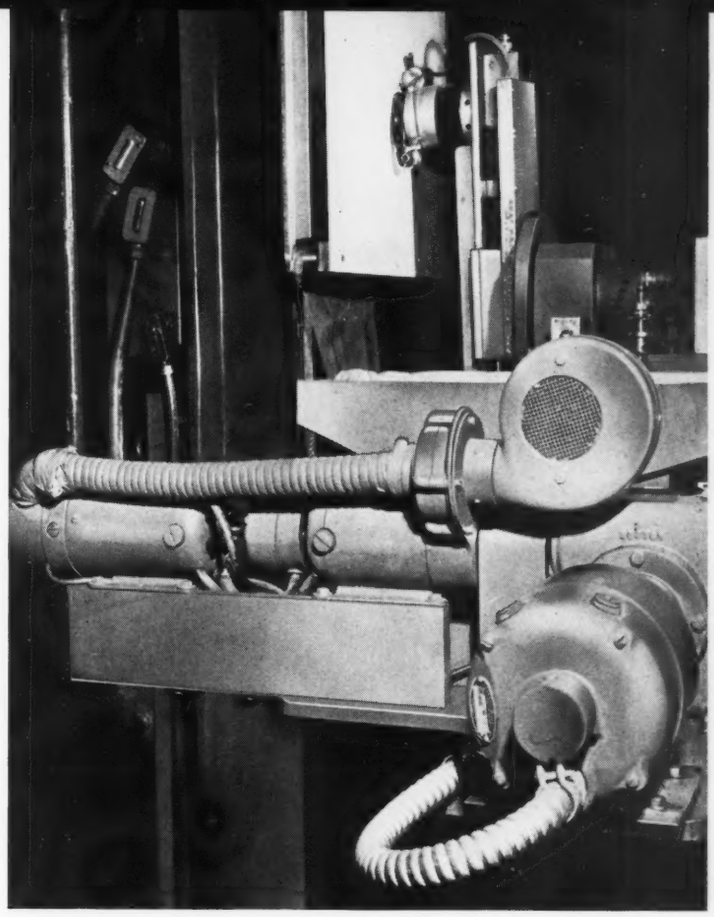


Fig. 3. The arm on which the photo-electric cell is adjustably mounted excites two selsyn generators which transmit current to receivers that operate motors to drive jig borer table

the blades will be produced to the desired shape and size.

An outstanding development in this plant is the method employed for producing the airfoil contour on production blades. This is accomplished on a battery of abrasive-belt machines, Fig. 5, that completely finishes the airfoil contour on high-temperature resistant alloy compressor and turbine blades that have previously been forged to approximately the desired shape. Similar to larger machines developed at the Hamilton Standard Propeller Division of the corporation during the war for the mass production of duralumin propeller blades, these machines have been built to Hamilton Standard design for this new application by the Sundstrand Machine Tool Co., Rockford, Ill.

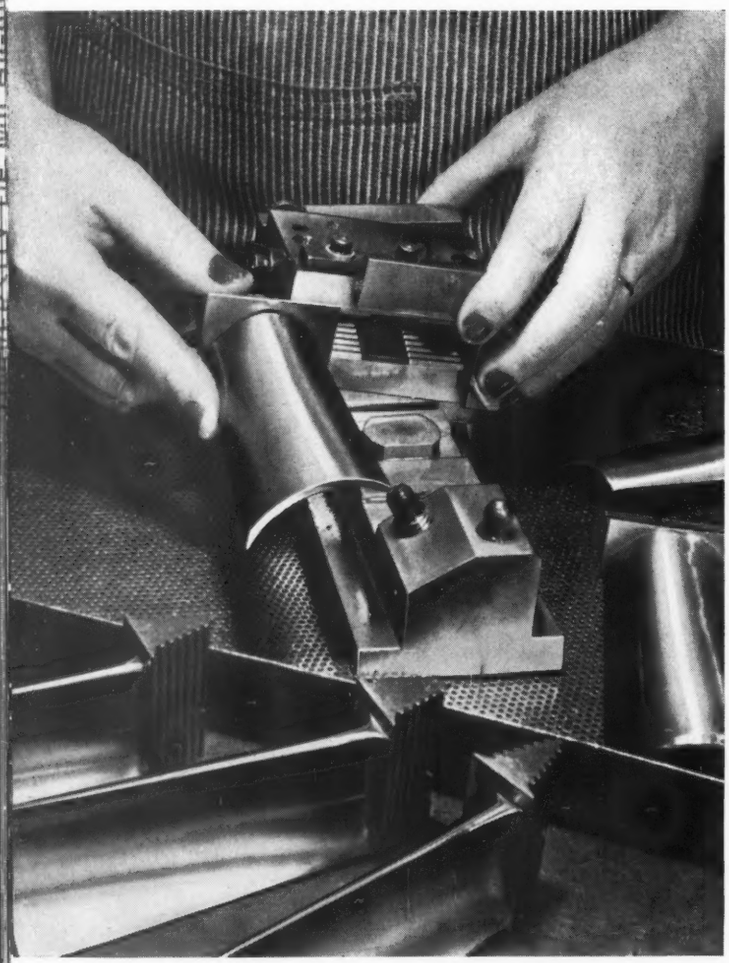
Hamilton Standard has patented the larger propeller machine, and has applied for a patent on the new turbine blade machine. Characteristic of abrasive belt grinders, they require relatively simple fixtures and can be set up quickly and easily. No expensive cutters are required, which naturally eliminates the man-hours ordinarily needed for sharpening and grinding such tools, and they are capable of high production rates. Of particular advantage in this application is the elimination of complex calculations in producing both the convex and concave surfaces of the airfoil contours.

The machine employs an abrasive belt which runs from a motor-driven pulley over a "tracker" pulley to a take-up pulley and thence to a forming roll ground to the contour of a blade master. The blade forging to be ground is securely held in a fixture under this forming roll, being located at its root, where the fir-tree pattern has previously been produced. To insure a high degree of accuracy, the forming roll contour is made ten times larger than the actual blade contour and is carried over its full peripheral surface. Although rough- and finish-grinding operations are actually performed on each blade, the machine is capable of completely finishing the blade from the rough forging.

In setting up one of these machines, the first

Fig. 4. Blade masters made in the jig borer by the use of an electronic contour follower are employed as templates in four-spindle Cincinnati Hydro-Tels. The template and follower are seen at the right in the illustration

Fig. 5. A battery of abrasive-belt grinding machines speeds up the production of jet-engine compressor blades



operation is to grind the forming roll in accordance with the contour of a master. The blade master is put in a compound fixture, as shown in Fig. 6, after which the fixture is placed in the machine, Fig. 7, directly below the tool-steel roll to be ground. For rough-grinding the cylinder, a 60-grit aluminum-oxide belt is used, with the abrasive side toward the cylinder and the smooth side passing over the blade master. The fixture and the cylinder are synchronized to oscillate together, so that the abrasive surface of the belt is forced into the cylinder, reproducing the form of the master at every point on the airfoil surface.

The forming roll is then hardened to from 50 to 55 Rockwell C, after which the belt is exchanged for one of 80 grit and the hardened roll is finish-ground. By merely reversing the belt so that the abrasive side is toward the fixture—an operation that takes about ten seconds—the machine is ready for the production grinding of compressor or turbine blades. When the forming roll wears, it is a simple matter to replace the master in the fixture, reverse the belt, and regrind the contour.

Because of the infinite variations in the twisted and tapered airfoil contours, which change constantly along the axis, the forming roll might be

Fig. 6. A blade master is securely locked in a fixture for positioning in an abrasive-belt machine of the type shown in Fig. 5

expected to have sharply changing contours, which would cause the belt to whip at thin sections of the roll. As a matter of fact, the finish-ground form roll is almost a true cylinder, since the desired contour is spread over the entire surface of the roll.

This is accomplished by offsetting the axis of the saddle type ball-center fixture relative to the axis of the forming roll in the horizontal plane. The line along which the fixture is offset is a mean axis which is the resultant of several axes through the blade, parallel to planes tangent to a flat surface. Since the tapered form of a blade makes it thinner at the tip than at the root, the fixture axis is also tilted, or offset, in the vertical plane. In addition, the position of the blade is adjusted in the vertical and horizontal planes relative to the forming roll to maintain the parallelism of its ground surface with the flat surface of the belt. To prevent the belt from moving along the axis of the pulleys, which would tend to make it run off the forming roll, the center axis of the roll must remain parallel with the pulley axes.

Primarily, the machine is hydraulically operated. A hydraulic cylinder actuates an arm to drive the upper and lower heads on which the forming roll and fixture are mounted. The drive is accomplished through the engagement of double, or split, racks on the arm with pinions on the heads. The racks are set slightly out of alignment with each other to eliminate backlash in the pinions which engage the rack sections. The reciprocating movement of the racks drives the pinions, thus obtaining perfectly synchronized oscillation of the heads.

In addition to its oscillating movement, the head on which the forming roll is mounted moves up and down on guides to feed the roll into the work and to permit loading and unloading the fixture. This is accomplished by a hydraulic cylinder which operates a set of clutches to move a screw which raises and lowers a bar at the rear of the machine. A cam mounted on this bar feeds the forming roll into the work a predetermined amount with each complete oscillation. A feed adjustment at the front of the machine provides a range of 0 to 0.005 inch feed per cycle. For most blades, a feed of 0.0004 to 0.0008 inch per cycle is employed.

Another interesting feature of this machine is the tracker mechanism, which keeps the belt aligned in a straight path. Two air jets, one under each edge of the belt, are operated from the plant air line and are connected to a double-acting, double-end air cylinder. Each end of the cylinder piston is connected to a pivoting yoke that supports the tracker pulley. This arrangement may be seen in Fig. 8, where an operator is shown changing a belt.

As the belt travels over the jets in a straight path, it just covers them, and closes them off. However, when the belt veers to one side or the other, air escapes from the exposed jet, thereby unbalancing the cylinder pressure at one side of the piston. As a result, the piston moves in the direction of the least pressure and pulls the yoke and pulley over to realign the belt.

This mechanism also prevents the use of a belt that is scuffed or worn at the edges, since under such conditions, the valve action described above would be continuous, which would indicate to the operator that the belt needed attention. The importance of replacing scuffed belts arises from the need to maintain the correct packing height, or radius, just above the root of the blade. This radius is produced in another operation, which is carried out with extreme care to avoid setting up strains in this portion of the blade.

As additional protection of the blade at this point, carbide inserts are placed on the fixture

Fig. 7. The forming roll is ground to conform with the contour of the blade master, which is held in a fixture beneath the roll

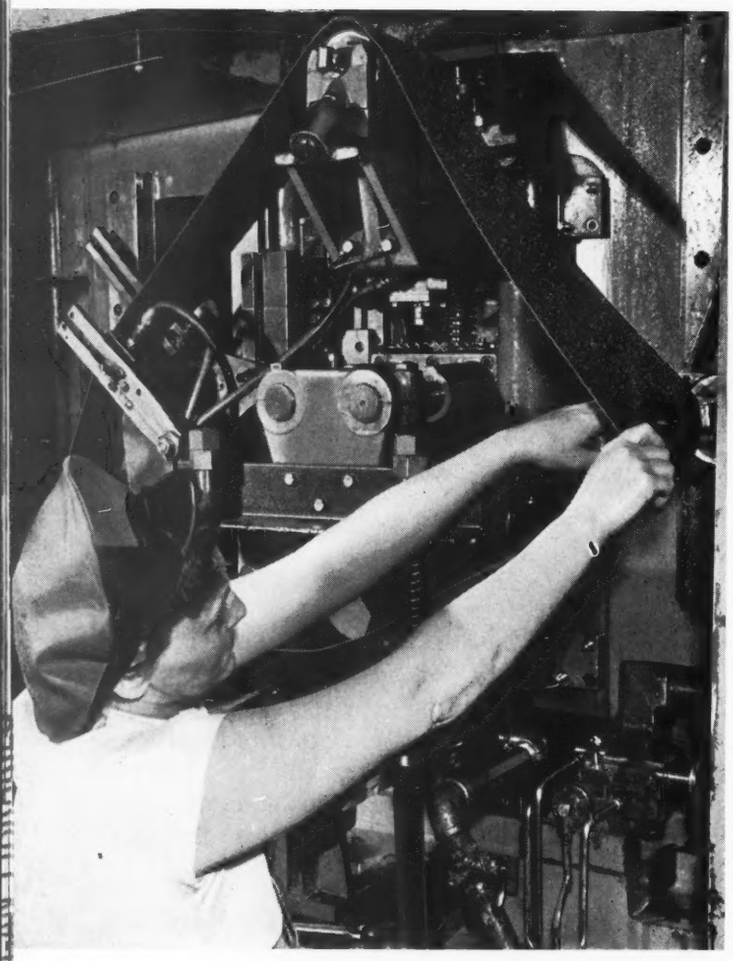


Fig. 8. Changing abrasive belts in these special machines requires about ten seconds

between the belt and the root of the blade. Such inserts are also used against the opposite edge of the belt to assist in keeping it in line, since the forming roll is slightly greater in width than the length of the blade.

The belts used in these machines, made by Sandpaper, Inc., Rockland, Mass., are about 108 inches long and 5 inches wide for blades used in the J-42 engine. They are run at approximately 6000 surface feet per minute, removing 0.060 to 0.090 inch of stock from each side in the rough-grinding operation. It usually requires seven or eight minutes to complete this operation on one side, including loading and unloading the fixture. At present, about fifteen blades can be completely rough-ground before it becomes necessary to replace the belt.

A stress relieving operation is performed after rough-grinding, following which the blades are ground to size and to a surface finish of 20 to 25 micro-inches, r.m.s., the amount of stock removed being about 0.030 inch on each side. The time required for finish-grinding one side is about four and one-half minutes, including loading and unloading. Approximately thirty blades are completed before replacement of the belt becomes necessary.

In both rough- and finish-grinding, a generous flood of a standard oil-base coolant is used. The heat developed in grinding blades in this manner is constant throughout the whole part, so that no warpage occurs. Since the belts are about three times as long as the circumference of comparative grinding wheels, and are exposed to air on both sides during a good part of their revolution, they run cool. They also rid themselves of work particles as they bend and straighten in each circuit around the pulleys.

Internal contours, or the concave surfaces of blades, are ground by positioning the belt between idler pulleys located over the forming roll in some machines that are specially set up with internal grinding fixtures. These operations are essentially the same as the others, except for the positioning of the belt. Inasmuch as the machines can be operated automatically, the operators are free to inspect the finished blades as they are produced. By the use of six-stage guillotine gages, the blades are checked to within 0.002 inch of the nominal contour required.

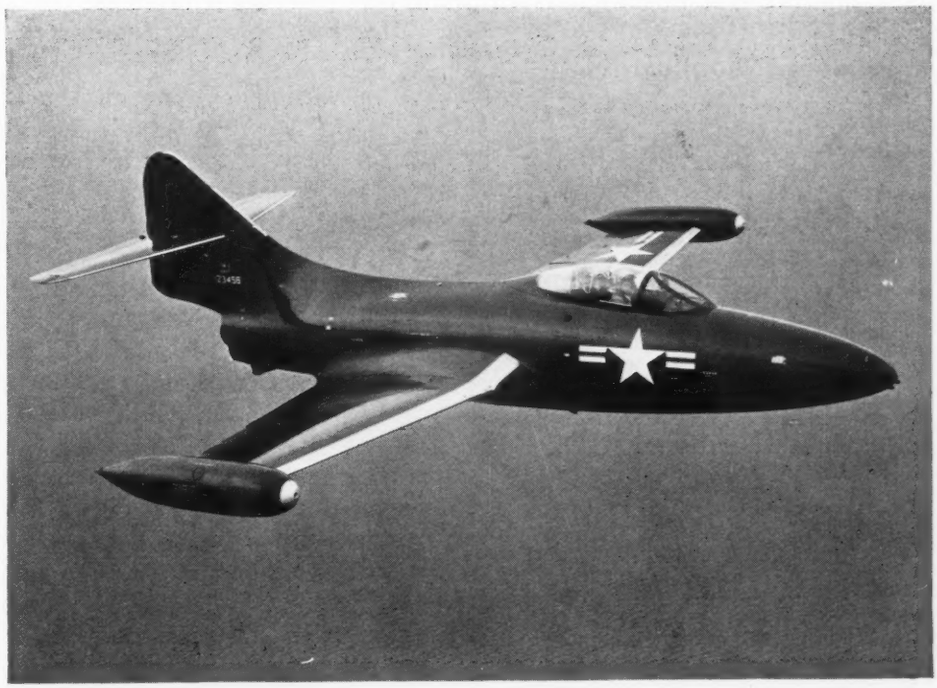
Final inspection of all blades is quickly accom-

Fig. 9. A Sheffield air gage is used to check contour of jet-engine turbine blades

plished on a production basis, by an eighteen-column "Precisionaire" fixture developed by the Sheffield Corporation, which is shown in Fig. 9. Which this equipment, the blades are inspected as rapidly as they can be loaded into and unloaded from the gaging position. No minimum or maximum master gages are required for setting up this contour measuring fixture. A carefully calibrated blade is used to provide a mean contour from which gage-blocks are built up to locate the two gaging head mounting plates or stages for the upper, middle, and lower points to be checked. The gaging heads are then clamped in position and feeler gages are employed to set up this basic unit for a theoretically perfect blade.

The three levels in the two mounting plates are aligned with each other, and each level has three pistons which contact the blade to be checked. This gives eighteen gaging points—a set of three contact points on the concave side of the blade at each of three levels, and a set of three on the convex side at each of three levels. The eighteen columns of air, each supporting a float, are connected by tubes to each of the eighteen contact pistons at the mounting plates. When the contour of the blade being measured depresses a piston, or contact point, the piston recedes and allows air to escape from the column to which it is connected.

The air that escapes permits the float in that column to drop, so that, in operation, the eighteen floats form a graph of measurement of the blade, which can be read at a glance by calibrations on the columns. Tolerance lines on the face of the columns facilitate this reading. In this way, the inspector can quickly determine where, and how much, the contour of a faulty blade deviates from the permissible tolerance. This instrument is so designed that it will accommodate a wide variety of blades, and can be easily adjusted to suit changes in blade design.



Grumman F9F-2 Panther powered by the Pratt & Whitney J-42 turbo-jet engine

Northrop

Northrop F-89 "all-weather" jet interceptor

Fluoroscopic Inspection of Aircraft Castings is Fast, Economical, and Accurate. The Principles of This Non-Destructive Method of Inspecting Vital Castings and its Application are Described in This Article

By
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and
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X-Ray Products Corporation
Los Angeles, Calif.

LIGHT metal alloy castings, particularly aluminum and magnesium, are assuming an increasingly important role in the construction of the present-day airplane. The demand for heavier load carrying capacity, together with increased speed, has resulted in the development of light metal alloys suitable for casting purposes that are far superior to those available for similar applications even in the Second World War. Designing engineers have taken advantage of the additional strength inherent in these new alloys by reducing the cross-section of castings to the minimum.

It is important that the internal condition of every piece cast of these light-weight materials be known. Assurance of soundness, and thereby safety, can only be had through proper non-destructive inspection methods, because the part must not be unduly strained or stressed in testing. One of the methods that was relied upon during the last war and is being employed to an even greater degree during the present emergency is inspecting by means of X-ray or radioactive materials. The radiographic method was almost universally employed. In this practice, as is well known, the X-ray equipment produces photographic negatives that indicate the presence of internal flaws in castings.

An important departure from that practice has been made by Northrop Aircraft, Inc., Haw-

Checks All Castings by Fluoroscopy

thorne, Calif. This company employs a fluoroscopic method, which eliminates the need of negatives, permits the examination of castings from any angle in rapid succession, and enables the instant determination of defects or discontinuities through the eyes of the operator. Obviously, the fluoroscopic method is cheaper than the radiographic method.

All aluminum and magnesium castings used by Northrop are checked by the fluoroscopic method. Some idea of the magnitude of this inspection practice can be had from the realization that the F-89 Scorpion alone contains nearly two hundred such castings. The application of fluoroscopy by this company is not limited to castings, the method also being used to inspect plastics and other materials. Welds can be checked and the action of instruments, switches, etc., embedded in metals or plastics can be observed in motion.

The simplicity of the fluoroscopic method will be understood from Fig. 1. The work is positioned at the required angle on a conveyor table beneath a clear plate of lead glass and viewed directly through the lead glass without the use of any mirrors. The casting can be tilted or completely turned over to insure thorough and rapid inspection.

Before discussing the results obtained with fluoroscopy, it would be desirable to outline the difference in principle between the fluoroscopic and radiographic methods, as applied in shop practice, and to briefly describe the fluoroscopic equipment employed. From Fig. 2 it will be seen that in radiography, the X-rays pass downward from the cathode and anode through the casting and then through the photographic film. In the fluoroscopic equipment, the X-rays pass upward from the cathode and anode through the casting and a screen to the leaded window.

The X-ray equipment used for medical fluoroscopy, unlike that used for medical radiography, is not so easily adapted to industrial purposes for several reasons. In industrial fluoroscopy, continuous and intense radiation at relatively high voltage is required. Besides, the source of radiation—that is the focal point of the X-ray tube—must be small, so that a reasonably clear image will be obtained. Although X-ray tubes and generators of extremely high intensity are not commercially available at this time, it has been found that certain components of the equipment now on the market will give excellent results for the purposes intended.

After the X-ray beam has penetrated the part to be examined, enough of this radiation must reach the fluorescent screen to obtain a brightness level in the area to be examined that is consistent with the limitation of the human eye. X-ray tubes generating as much as 25 to 50 milliamperes on a continuous basis would be desir-

Fig. 1. Operator of fluoroscopic inspection equipment viewing a casting through the leaded glass window

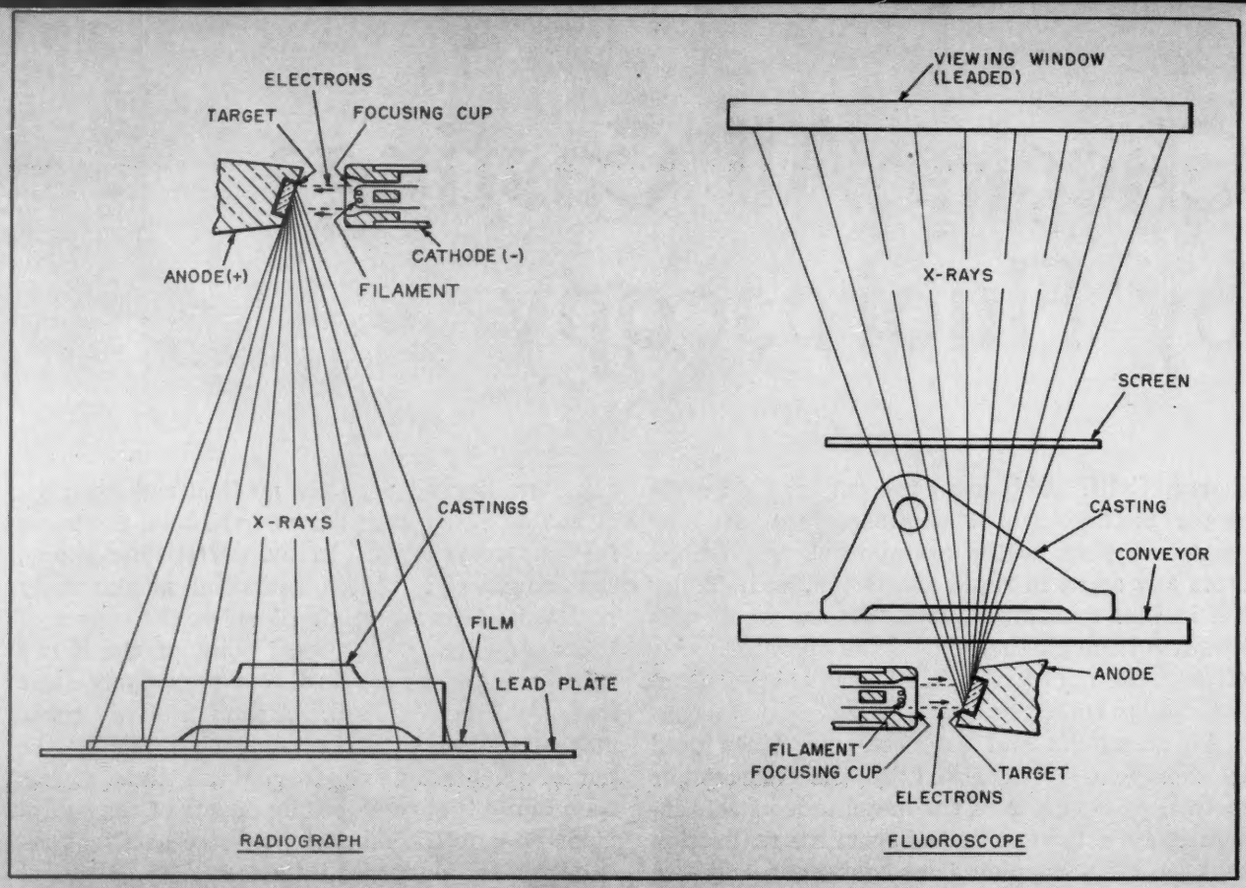

Fig. 2. Diagram showing comparative principles of radiographic and fluoroscopic inspection of castings

able, provided the focal point were small and the penetrating power were about 150 kilovolts or more. Since such tubes are not generally available, tubes and generators operating from 6 to 10 milliamperes at the voltage mentioned are employed.

To obtain the high fluorescent brightness level required for industrial applications, the distance from the X-ray tube to the fluorescent screen had to be decreased, thus limiting the physical size of the parts that could be examined. The thickness that can be penetrated is, of course, largely governed by the kilovoltage available. In spite of all these limitations, it is amazing to note how many parts employed in aircraft structures can now be successfully examined by means of the fluoroscope. Typical examples of such parts are shown in Figs. 3 and 4.

Through actual experience in this field, it was found that at approximately 100 kilovolts and 10 milliamperes, with a distance between the source of radiation and the screen not exceeding 20 inches, aluminum and magnesium castings can be successfully fluoroscoped, provided the cross-section to be examined does not exceed 1/2 inch. The cross-sectional thickness can be as much as 1 1/8 inches if the kilovoltage available is about 150 and the quantity of radiation from 10 to 15 milliamperes. If the part is such that it does not require a distance of 20 inches between the source of radiation and the screen, a 10-milliampere capacity generator will prove sufficient.

These figures are based upon the use of the latest type of industrial fluoroscopic screens and direct reading of the image through a sufficient number of clear plates of lead glass without the use of mirrors. When it is essential to employ mirrors, the brightness level of the illumination will be reduced about 10 per cent for each mirror used in the system; and unless such mirrors are hermetically sealed to retard normal oxidation, additional reduction in brightness must be anticipated.

One of the very important requirements in industrial fluoroscopy is the provision of adequate means for protecting the operator, especially in direct viewing equipment where mirrors are not used. Much greater protection against radiation than is provided in some medical equipment must be supplied. This is due to the fact that the interpreter of an industrial fluoroscopic image is practically continuously viewing the screen in a manner similar to viewing a television set, as shown in the illustration, Fig. 1. It is therefore essential that the entire equipment be so arranged that no radiation of any kind can reach the interpreter, or

any other person in and about the industrial fluoroscope. Industrial fluoroscopy has one advantage in this respect over medical fluoroscopy in that the parts to be examined can be placed in a totally enclosed chamber if necessary, whereas in medical fluoroscopy it is not feasible to do this.

It is of interest to note the means that have been provided to enable the operator of the fluoroscope to know whether the parts he is examining are being completely penetrated and whether the definition of his fluoroscopic image has as much detail as he believes it has. A so-called "master penetrameter," Fig. 5, has been designed which is similar to ordinary penetrameters except that it is approximately 3 inches square and is equipped with sixteen holes of various diameters and depths.

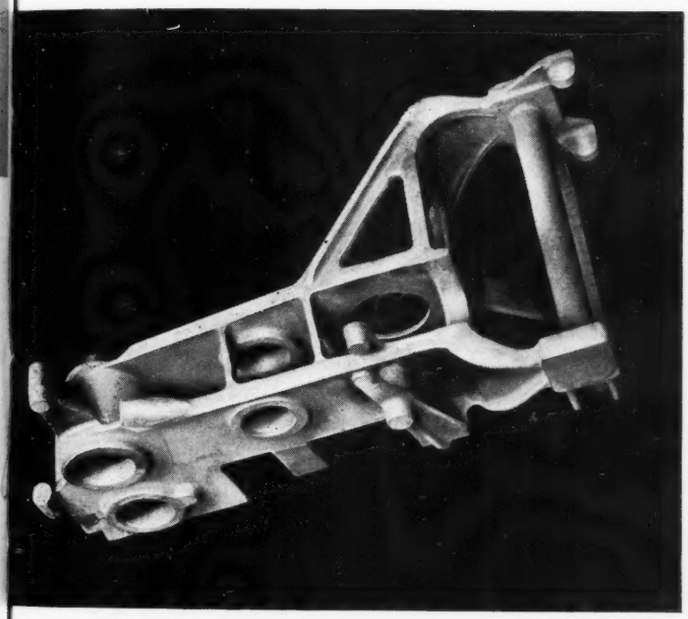

Fig. 3. (Above) Seven-pound cast-magnesium elevator control drive housing inspected by fluoroscopy

The master penetrameter is 0.125 inch thick, and is made of the same material as the part being examined. The smallest holes in it are 0.030 inch in diameter and are arranged in a row of four. One of these holes is drilled completely through the plate, while the other three are drilled to depths of three-fourths, one-half, and one-fourth the thickness of the plate, respectively. There are three additional rows of holes, which are drilled 0.047, 0.062, and 0.094 inch in diameter, and to the same depths as the 0.030-inch holes.

The master penetrameter, when placed in the X-ray beam, should appear clear enough so that at least fourteen of the sixteen holes are easily discerned. If not, either the dark adaptation of the operator's eyes is incomplete, the X-ray equipment is not working properly, or the distance from the screen to the platform supporting the parts is too great. The operator can also use the image of the various holes in the master penetrameter to judge the size of similar holes in the part being examined.

Another aid is provided for the operator in the form of X-ray reading guides, such as the one illustrated in Fig. 6, which are available for various castings. With these, the interpreter knows where the critical areas are in each casting.

A question frequently asked regarding fluoroscopy is "Will it replace an X-ray picture?" The answer is definitely "No!" An X-ray picture, or radiograph, especially with the various types of film emulsions now available, is optimum in its resolving powers, as it can record definition which, in some cases, is visible to the human eye only after the film has been enlarged. A fluoroscopic image, on the other hand, presents a di-

Fig. 4. Typical aircraft aluminum-alloy castings ranging in weight from 2 ounces to 3 pounds

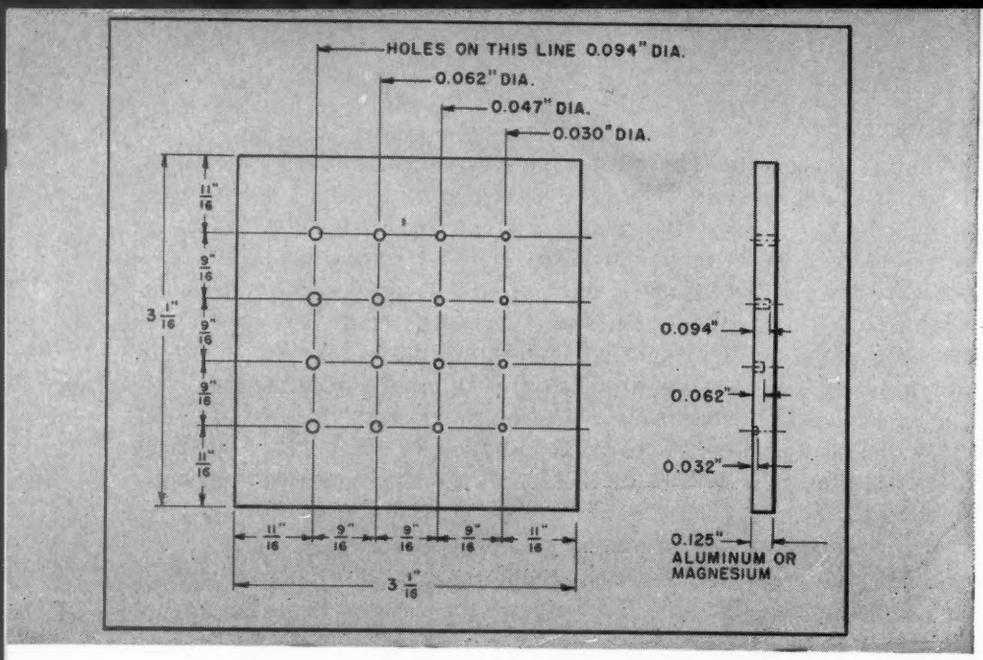

Fig. 5. Master penetrameter used at Northrop Aircraft, Inc. for determining whether or not parts being examined by fluoroscopy are being completely penetrated

rect reading medium whose definition is much less than that of an X-ray film, but in practical application is so good that it could, under favorable conditions, be almost solely depended upon for the examination of light metal alloy castings.

As a matter of fact, in the case of the majority of light metal alloy castings used in the aircraft industry, fluoroscopic inspection will reveal all cavities or cracks of a size that would render such parts rejectable. A fluoroscopic view of an aluminum bracket that discloses a crack around the boss is seen in Fig. 7.

In other words, an X-ray picture will give more information regarding minute discontinuities than fluoroscopy, but when it comes to making a decision as to the usability of a part, the fluoroscopic image will provide enough information to permit an able interpreter to judge as to its acceptability.

In radiographic inspection as now practiced, the use of fluoroscopy combined with percentage radiography would, of course, give a much better result than percentage radiography alone. With this combination, no casting having large discontinuities would ever reach the assembly line. Rigid inspection requirements laid down by the Air Force and the inspection departments at Northrop Aircraft, Inc., necessitate percentage radiography in this plant, as well as fluoroscopic inspection. The radiographic inspection ranges from 10 to 25 per cent, depending upon the ultimate use of the casting and other factors.

The over-all cost of fluoroscopic inspection, if properly performed, is less for a complete X-ray examination system than it is for a radiographic percentage system. Modern X-ray equipment for fluoroscopic examination such as illustrated in Fig. 8 is more than sufficient to weed out castings with rejectable defects in accordance with present standards of acceptance by the major aircraft companies.

Although micro-shrinkage in magnesium castings and fine gas porosity in aluminum castings are occasionally observed by means of the fluoroscopic method, it is not, in the present form, reliable enough to be used for checking conditions of that type, and radiographic means should be used when such conditions are a determining factor in the acceptability of castings. Enough data has been accumulated, however, to say with certainty that gas holes and other cavities as small as 0.050 inch in diameter or 7 per

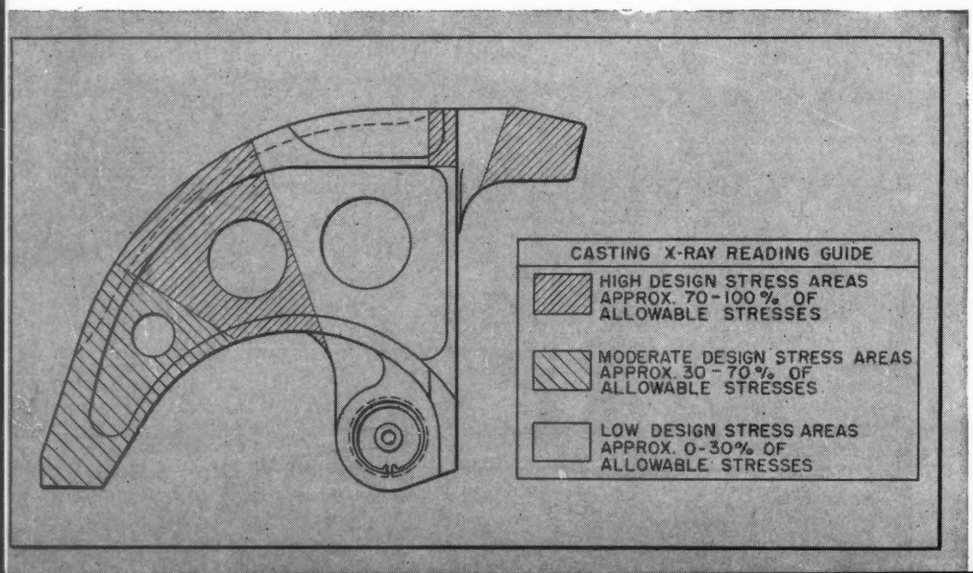
CASTING X-RAY READING GUIDE
HIGH DESIGN STRESS AREAS APPROX. 70-100% OF ALLOWABLE STRESSES
MODERATE DESIGN STRESS AREAS APPROX. 30-70% OF ALLOWABLE STRESSES
LOW DESIGN STRESS AREAS APPROX. 0-30% OF ALLOWABLE STRESSES

Fig. 6. A typical casting X-ray reading guide for stress reference in inspecting castings by fluoroscopy

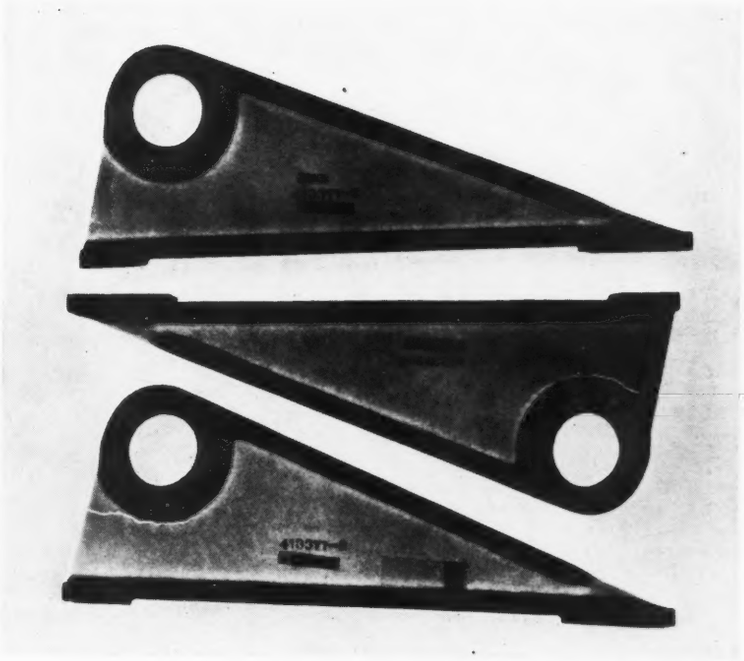

Fig. 7. Fluoroscopic view of an aluminum bracket that reveals the presence of a crack around the boss

cent (whichever is the larger) of the total thickness of the cross-section in which they occur can easily be found by fluoroscopic means.

Such discontinuities as shrink cavities, are somewhat more difficult to observe, and experience indicates that the smallest ones that can be detected with ease are those that are at least 0.080 inch in their smallest dimension or 10 per cent (whichever is the larger) of the total thickness of the cross-section in which they occur. The foregoing takes into consideration a certain amount of eye fatigue on the part of the operator, because under ideal conditions, as previously mentioned, much smaller discontinuities are visible on the fluoroscopic screen.

Fluoroscopic inspection is not intended to completely replace radiographic inspection, but is considered as a supplemental means of rounding out the X-ray inspection picture, so as to permit a more thorough analysis at an economical cost of many of the items that go into an airplane, on a 100 per cent basis. In view of the acute film shortage encountered during the last war and the increased use of X-ray film since then, it is possible that this material will again be in short supply. Rather than impair the safety of an airplane by reducing radiographic inspection to a percentage control only to meet such an exigency, the employment of fluoroscopy wherever and whenever feasible is desirable.

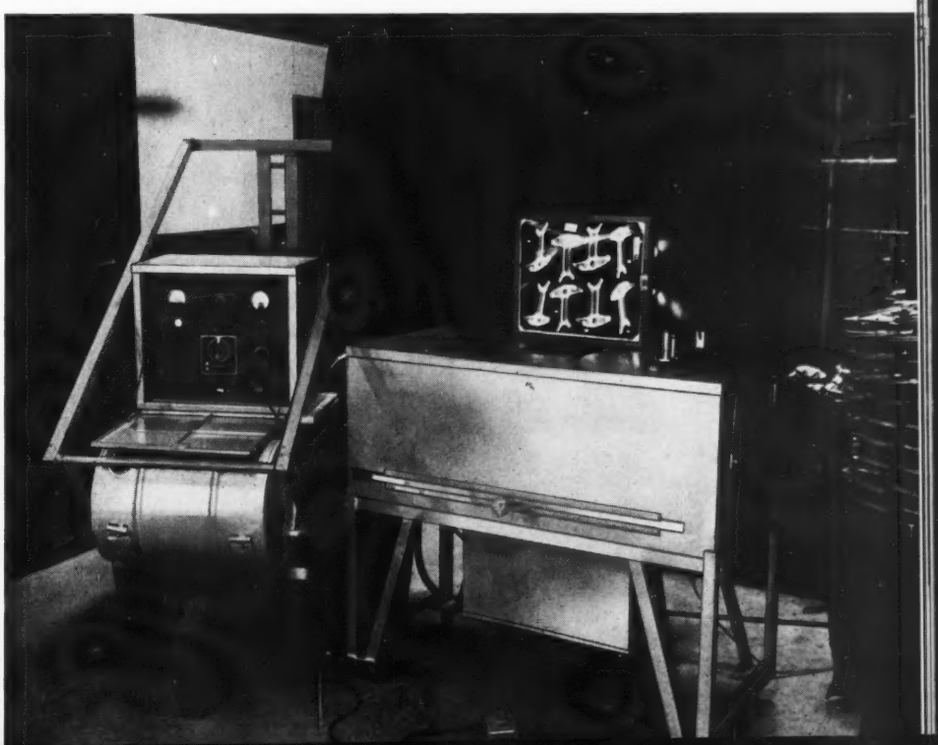

Fig. 8. Viewing screen showing fluoroscopic images as seen by the operator when looking into a small window in the fluoroscope

Electroforming

North American F-86 Sabre jet fighters fly over Mount Fujiyama on their way to combat in Korea

Kinds of Metals Deposited, Types of Molds and Matrices Used, and General Procedure Followed in Making Airplane Parts and Molds by the Electroforming Process

By
G. B. LEWIS, General Foreman, Assembly Tooling
and
L. FROST, Tool Engineer
North American Aviation, Inc.
Los Angeles, Calif.

Speeds the Production of Aircraft Parts and Tools

THE electroforming process is being employed by North American Aviation, Inc., both for the complete production of certain airplane parts and for making dies and molds for glass cloth laminate and glass mat parts. Details of the process employed were developed by the Bone Engineering Corporation, Glendale, Calif.

Electroformed molds have certain advantages compared to conventional molds. Of these, the most outstanding are lower cost; higher quality surface finish; less weight; dimensional stability, which facilitates exact duplications; ease of heating and adaptability to hot water and steam curing; ease of releasing work-piece; and elimination of blue blocking (stand mock-up used).

There are several different methods by which an electroformed mold may be built up. The surface finish and strength requirements, as well as shape and size, determine the method to be used. For example, in making a mold for cast resin parts, a mirror surface such as indicated at *A*, Fig. 1, is necessary. The procedure to meet this requirement is as follows:

1. Preparation of matrix to give the best possible surface, as will be described later.
2. Chemical deposition of silver (flash cover).
3. Electrodeposition of nickel, approximately 0.020 to 0.030 inch.
4. Electrodeposition of copper to the desired thickness.
5. Electrodeposition of nickel or iron to 0.062 inch thickness or more as required to maintain strength of mold.
6. Removal of electroformed mold from the matrix.
7. Dissolving of flash coating of silver, leaving a nickel finish.

If the matrix has been properly prepared, no polishing of the mold surface will be necessary. The finish obtained from this method is far superior to all others.

When the mold is to be used as a pressure vessel into which air is injected at a pressure above that which is normal for molding low-pressure laminates, an all-nickel or nickel-faced iron construction is used, the total thickness of metal being 3/8 to 1/2 inch (see *C*, Fig. 1).

The method shown at *B* is used on the majority of molds, where the vacuum bag or flexible vinyl application method of holding the part is employed and the pressure is not great. The procedure in this case is as follows:

1. Spraying of matrix with a conductive lacquer.
2. Electrodeposition of copper to the desired thickness.
3. Electrodeposition of nickel or iron to 0.062 inch thickness as a backing to maintain the strength of the mold.
4. Removal of mold from matrix by hand sawing or machining the edges and polishing of copper surface.
5. Electrodeposition of nickel to 0.004 inch on polished surface.
6. Polishing of nickel surface.

In the design of electroformed tooling, several important factors must be considered. First, the correct application must be decided upon, and then method of build up must be determined. It may be noted that a 3/16- to 3/8-inch wall thickness will suffice to withstand the pressures required for low-pressure laminating. A sufficient mold area must be allowed beyond the part trim, say, a minimum of 1 1/4 inches. Incorporate flanges where necessary, and avoid all mechanical depressions in mold surfaces and land areas. Design molds so as to eliminate the need for welding to an electroformed cavity wherever possible. When welding is necessary, however, it should be accomplished while the mold is on the matrix.

Designs should be made to incorporate both left- and right-hand parts in one mold if possible, and dimensions for flanges, radii, and the location of heating tubes must be indicated. It is necessary to determine back-up, bracing, and handling methods. In addition, the design should close off all die ends in the electroforming operation and should utilize vinyl rubber applications on deep cavities and complex contours. Last, it is well to avoid mating molds if possible on large size dies.

The electroformed tool may be backed up by one of several methods to obtain additional strength. Some materials used also aid in the

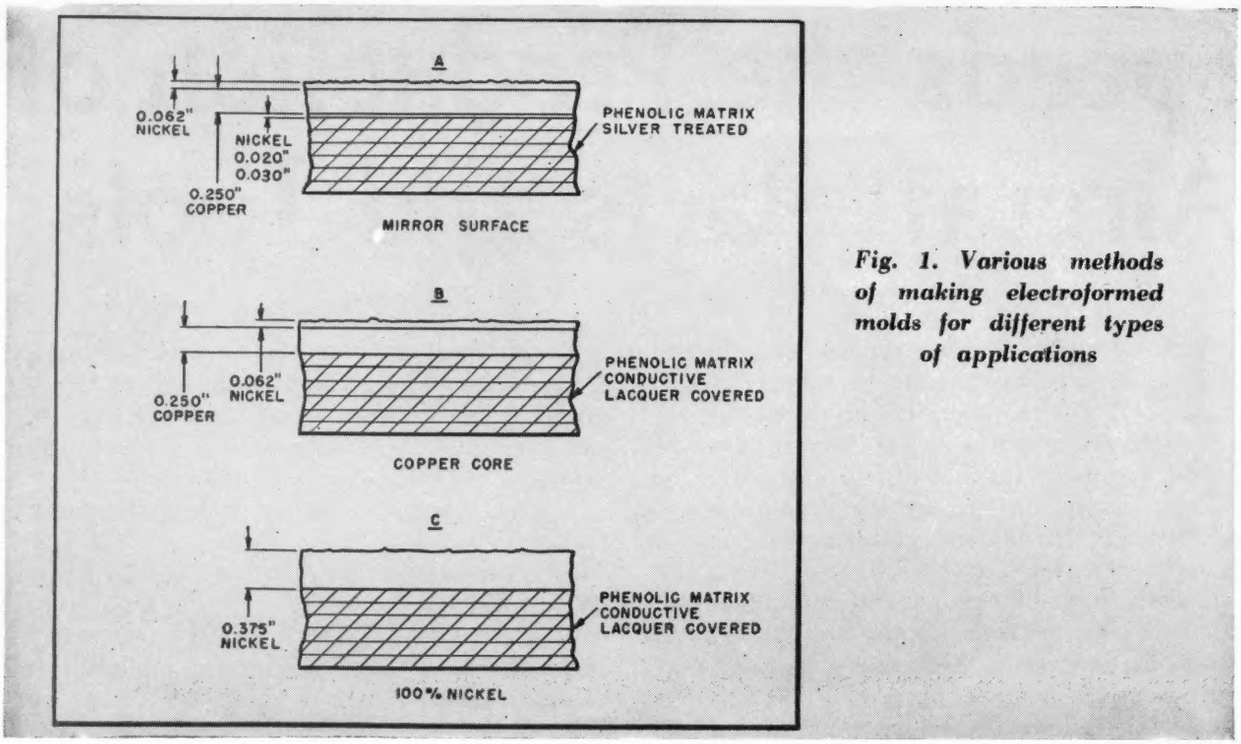

Fig. 1. Various methods of making electroformed molds for different types of applications

heating of these molds. Hydrocal has been employed successfully, and this has a good compressive strength when used as a back-up material. Glass cloth or glass mat may also be used as an insulating back-up, since both have excellent strength and are good insulating materials. A high heat-resistant phenolic resin may be used if it is enclosed in steel. The mold, itself, should be supported by steel work, and soft copper tubing may be installed in accordance with heating specifications, and attached by a copper, aluminum, or zinc metal spray. Where the tubing contacts the electroform mold, a low melting alloy, such as "Cerromatrix" or "Smooth-On," can be used to build up a fillet before metal spraying. This increases the heat conductivity of the tubes and reduces the amount of metal required in spraying, as well as the time necessary for this operation.

The matrix, or master, for an electroformed mold has great importance, as the electroformed mold will conform to and pick up any impression on the matrix. Obviously, the matrix should be given the same care as any master tool. Once the electroformed mold is made, it is not desirable to rework; therefore, careful inspection is essential to minimize errors in the matrices.

Several materials can be used to produce a satisfactory matrix. Of these, the least costly, and possibly one of the best, is phenolic resin. Matrices may be made from plastics (phenolic, acrylic, etc.), steel, or aluminum, and other

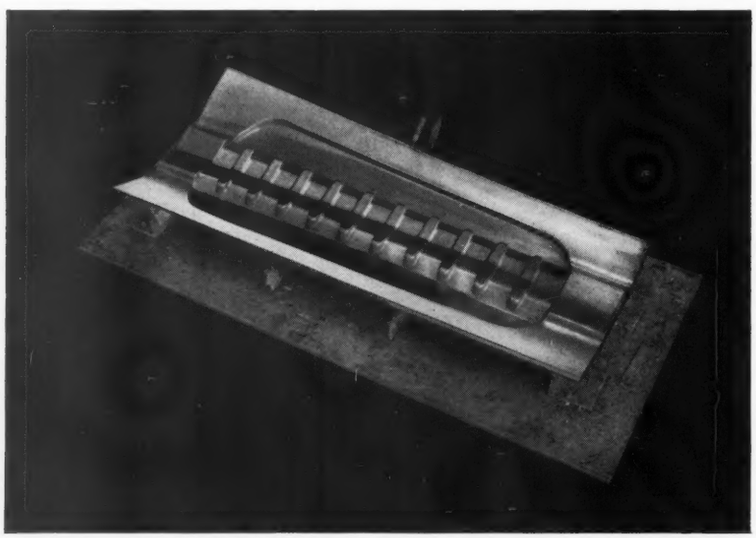

Fig. 2. A single-cavity electroformed mold for producing a glass cloth aircraft part

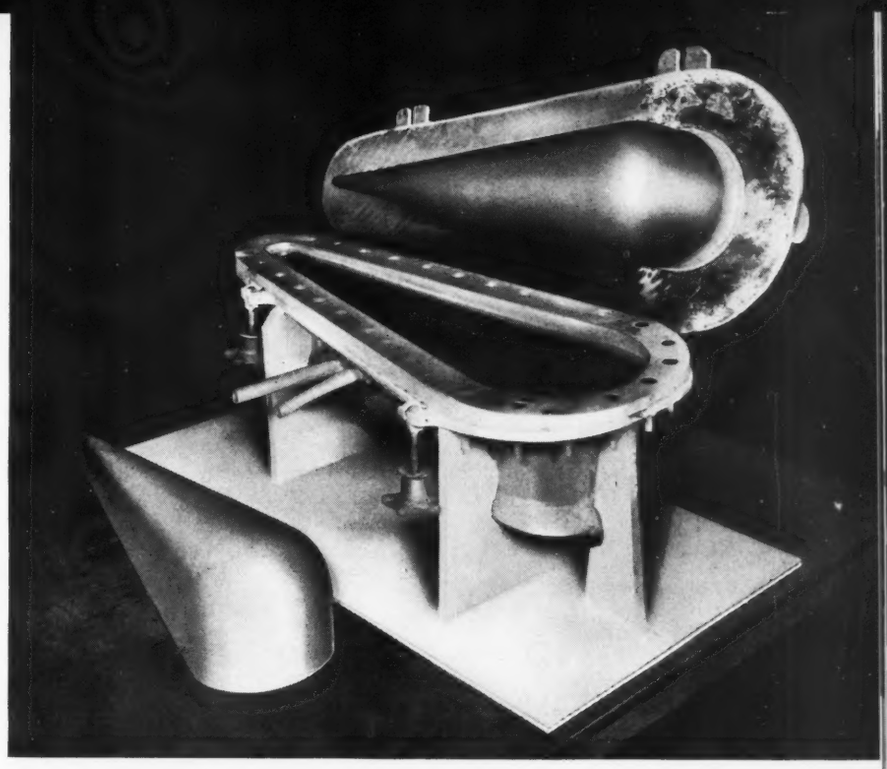

Fig. 3. Different types of materials can be used as the male members for electroformed molds. In this case, the punch is made of a vinyl plastic

alloys. However, the choice must be carefully determined to suit the surface finish required. The matrices used for electroforming should have a porosity-free, smooth surface, and be impervious to the bath liquids.

A means of producing a super-smooth matrix from a mediocre casting has been developed on a small scale. This method involves dipping the matrix in recording lacquer several times until the irregularities are covered and a smooth finish is obtained. This process is not practical at the present time for large matrices because of equipment limitations.

In building a phenolic matrix, a core can be utilized. This is done primarily to decrease the amount of phenolic material used, and lessen the cost of the matrix, as well as to eliminate shrinkage problems. The core is often made from hard wood or Masonite. It must be completely enclosed with phenolic plastic to prevent swelling due to moisture, which would cause the matrix to crack. A matrix thus damaged during the electroforming process injures the mold. Molds for making parts similar to large radomes require matrices of the ribbed type to provide the required strength. Usually the matrices are ribbed to a 2-inch wall thickness. Surface finish is also important.

A recent development in plastic tooling at North American Aviation has produced an almost perfect matrix surface. In this process, an unfilled resin is brushed directly on the surface

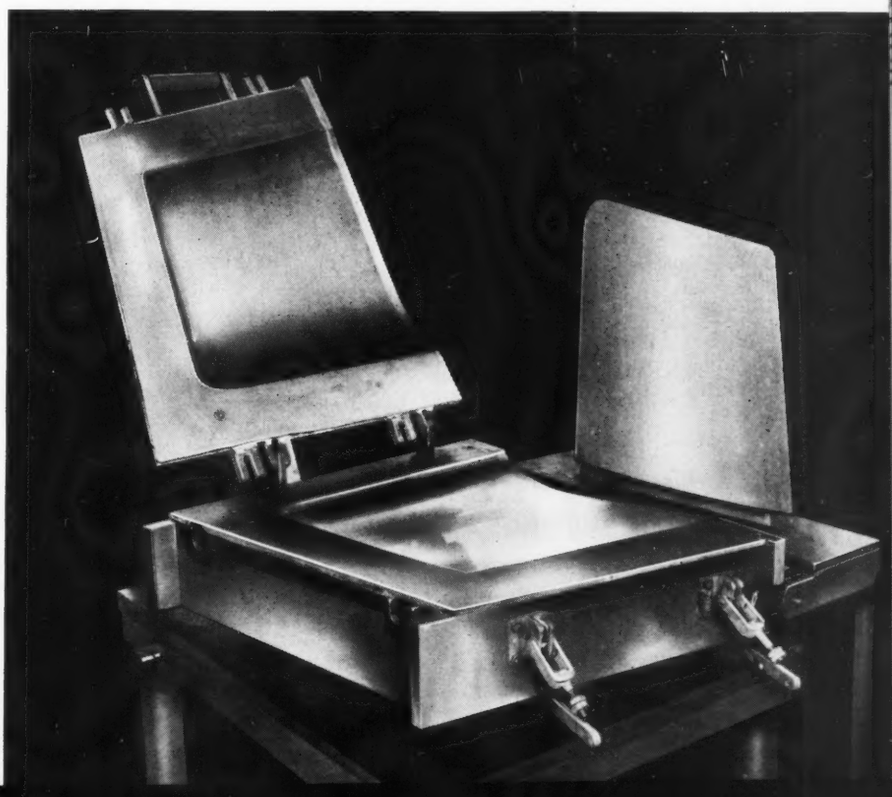

Fig. 4. Electroformed mold and aluminum punch employed in producing rudder tip seen at right

of the prepared plaster and allowed to jell, after which filled resin is added to make up the balance of the casting. Several castings of this nature have been made successfully.

There are various types of molds that may be made by the electrodeposition of metals. Among these are single-cavity molds which may be used with a vacuum bag application or by utilizing a vinyl rubber membrane backed up with a cast-aluminum pressure plate or a glass cloth pressure plate. This type of mold (Fig. 2) is used most, since it does not involve matching matrices or molds. It is very satisfactory for producing the majority of glass cloth parts, since only one side of these parts need be nearly void free. This mold may also be employed as a pressure vessel, using a pressure plate and applying internal air pressure.

Matched cavity molds are essential for glass mat type parts, as well as for glass cloth parts that require high finishes on both external and internal surfaces; they are also necessary for casting resin parts. Matched cavity molds, when exposed to great pressures, such as those involved in press applications, must be produced by one of two methods. They should be constructed either of laminations of nickel and copper or 100 per cent nickel or iron.

The physical properties of electroformed metals will equal or exceed those of the same metals in cast, rolled, or forged form. Electrodeposited nickel having a tensile strength of 50,000 to 100,000 pounds per square inch can be applied by several types of baths. Close tolerances can be held in electroforming by using the correct matrices and employing precise controls in deposition.

Electroformed tools are readily adaptable for use with other tooling materials. Vinyl plastic, rubber, and aluminum cores are commonly used to form the male member for electroformed cavities in such applications as shown in Figs. 3 and 4. Metal spray is used almost exclusively to attach the heating tubes. A metal sprayed aluminum casting finished to a smooth surface has been found satisfactory for some uses as the male member when molding glass mat.

Vacuum pressure, using a pressure vessel application bag, is used on the majority of electroformed molds, but this does not produce the best part. When a part requires a "gel coated," void-free finish, a higher pressure is applied to the mold cavity by using a pressure plate actuated by air. A mold subjected to this higher pressure must contain a sufficient amount of nickel or iron to support the additional strain.

Electrodeposited metals are readily machined to a high quality finish. A large mold can be made in the same length of time as a small mold of the same shape, the governing factor being tank size. The electroformed type molds are easily repaired provided a drastic contour change is not encountered. If the mold face is damaged, the nickel-plated surface can be removed and the damage repaired with a solder having a melting temperature of between 475 and 650 degrees F., after which the nickel plating is restored. If the nickel surface is worn away by continual cleaning and polishing, the mold can be stripped and resurfaced and can be back in production in forty-eight hours.

An itemized cost record has been kept of a complete run of the T-28 airplane electroformed molds. These molds cover a variety of shapes and sizes, containing both complex and simple contours. Typical examples are shown in Figs. 5 and 6. The record showed that the over-all cost of electroformed molds averages 35 per cent less than similar tools in other stable conventional materials. The cost of electroformed tools includes the following items: Matrices; electroforming of molds (preparation, tank time, finish); heating installations on molds; frame and assembly work; and material (electroforming anodes).

The tooling for the T-28 plane was the first equipment of this kind to be produced by electroforming. A complete group of tools was planned,

Fig. 5. Mold produced by the electroforming process for making radomes

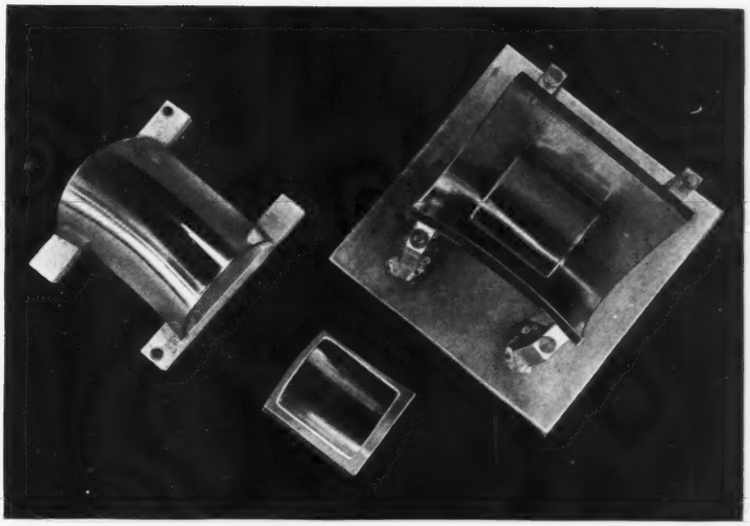

Fig. 6. Male and female members of an electroformed mold used for producing resin castings of the type seen below the mold

designed, and produced as a unit. Being the first effort along this line, many things were learned during the program which will improve future tooling and decrease the cost.

As a result of the experience gained in electroforming tools, the production of aircraft parts by the process has been facilitated. Because of the ability to deposit any desired thickness of metal on, or around, configurations that were impractical or impossible to fabricate by conventional methods, this process offers several advantages in producing many aircraft parts. It is especially useful in the production of parts for heat and vent installations.

In this work, several difficult problems existed before the application of the electroforming process. These were first, holding weight to a minimum; second, the inability to form extreme contours, sharp bends, etc., utilizing sheet material 0.006 to 0.015 inch; third, difficulties due to the fact that details of the configurations were fabricated in sections and subsequently welded together, which presented a serious coordination problem plus excessive hours for fabricating. Experience in electroforming definitely indicates that these problems can be eliminated. Furthermore, it is evident that there are many more applications wherein electroforming can be utilized on a sound economical basis.

Before adopting this method of fabrication, a number of factors had to be considered. First, it was necessary to investigate the possibility of electroforming production parts economically for airframe manufacturing. Attention was also given to the development of new materials for making low-cost matrices on which electroformed thin shell parts could be produced. Another point to be determined was what applications would lend themselves readily to electroforming techniques and the resulting physical properties of the electroformed metals. Finally, a cost comparison between electroforming and conventional methods of producing parts of aluminum, stainless steel, and glass cloth was made.

It was found that a wide variety of heat and vent ducts could be successfully electroformed, with few limitations on design. Airframe production details of electroformed metals, such as radar wave guides, rocket nozzles, pitot tubes,

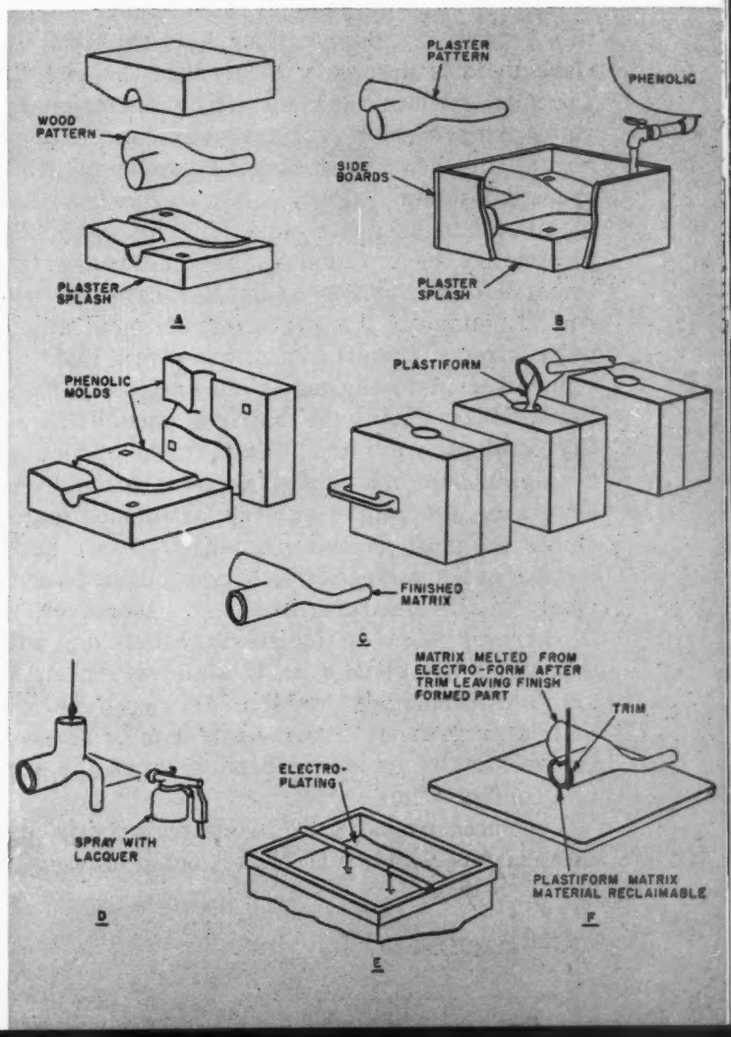

Fig. 7. Successive steps in the production of a heat and vent duct by electroforming

Fig. 8. Heat and vent ducts at the left and right were made by electroforming. The duct at rear was fabricated by welding 52S-O aluminum

etc., were produced in quantity. Moreover, it appears that the future development in matrices and techniques may include the electroforming of large air intake ducts, accumulator tanks, exhaust manifolds, wing tips, leading edges, etc.

Electroforming is playing an active part in large-quantity production of thin-walled parts, such as fountain pens, pencils, small tubing, etc. Although these details are not as complicated as some of the suggested details for airframe manufacturing, the same techniques can be employed.

In connection with tooling, the expenditure for this process is comparatively low, since only a slush mold is necessary to produce the matrix. The slush mold can be made of any dimensionally stable material that will produce a smooth nonporous surface on the matrix. Phenolic material, Palestic, dental stone, and electrodeposited metals can be used as a mold material. Phenolic plastic has been found to be the most satisfactory so far, and is easily fabricated with a smooth surface. An electroformed mold might be required if the production rate were high.

In addition to the materials previously mentioned for producing the matrices, phenolic resin, Cerro alloys, wax, and "Plasti-form," which is a sulphur-base material that is reclaimable at small cost, are employed. The last-named material is the most desirable because it has a hard smooth outer surface, which is duplicated accurately in the electroformed part. Moreover, it is extremely low in moisture absorption, will withstand the plating acids and temperatures, and is dimensionally stable in thin sections. A matrix made from "Plasti-form" can be slushed in five minutes or less, depending upon the size and configuration.

The metals most used in electroforming are nickel, copper, and iron. Nickel, being inherently corrosion-resistant and of the highest tensile strength, is preferred to either copper or iron for airframe detail parts. The electrodeposition of aluminum is believed possible; however, further research and development are necessary. The deposition of aluminum would, no doubt, open up a much larger field for electroforming within the airplane industry, as nickel would probably become critical in a national emergency. With this in mind, other materials should be considered for future development.

As far as the deposition rate of metals is concerned, a rate of 0.001 to 0.010 inch of nickel, iron, or copper per hour can be attained through one of several processes and baths. Ductile nickel of high tensile strength can be deposited in the thin cross-sections necessary for airframe parts, such as ducts, radar wave guides, accumulator tanks, etc. The design should facilitate electroforming where possible by allowing large radii and generous tolerances for thickness, and by eliminating the necessity of depositing metal into deep narrow recesses.

There are three basic types of nickel baths by means of which nickel can be deposited from 0.001 to 0.004 inch per hour, with a tensile strength ranging from 50,000 to 110,000 pounds per square inch. One bath produces a deposit of 50,000 pounds per square inch tensile strength, 150 Brinell hardness, with an elongation of 30 per cent. Another bath produces a deposit of 110,000 pounds per square inch tensile strength, 26 Rockwell C hardness, with 12 to 15 per cent elongation. By varying the operating conditions, deposits of any intermediate hardness and tensile strength can be produced. Nickel will retain its hardness at temperatures below 500 degrees F. Electrodeposited nickel undergoes a contraction in volume, which produces stresses and can

Fig. 9. An electroformed nickel aircraft part (right) compared with a similar part (left) made of stainless steel by conventional means

result in distortion. This is more prevalent in thinner sections, and can be remedied by annealing or low-temperature relief. Laminated deposits of two metals are sometimes used to gain maximum strength and rigidity.

The various steps in the production of a suitable matrix for electroforming a heat and vent duct are illustrated in Fig. 7. First, a wood pattern is made to drawing dimensions, as seen at *A*. Then, using the wood pattern, a split female plaster splash mold is constructed and from this mold, a duplicate of the wood pattern is made of plaster. One half of the split female plaster splash mold and the plaster pattern are shown at *B* prepared for the pouring of the upper half of the phenolic slush mold. The lower half of the phenolic slush mold is then cast against the completed upper half, using the same plaster pattern and similar techniques.

The two halves of the phenolic slush mold seen at *C* are now prepared by lubricating with D-200 liquid silicone. This allows easy release of the matrix. The slush mold is next clamped together, and all openings but one are blocked off, following which "Plasti-form," heated to a liquid state, is poured into the opening and slushed out after the desired thickness is attained. The mold is then opened and the finished matrix is removed.

Any minute porosity is filled and the matrix is sprayed with a conductive lacquer, as shown at *D*. The matrix is now ready for electrodeposition. The normal electrodeposition of nickel to the desired thickness is shown at *E*. This operation is followed by trimming to a scribed line, as seen at *F*, or trimming may be accomplished before the removal of the matrix. In the latter case, the matrix is removed after trimming by heating to a liquid state, the "Plasti-form" matrix material being reused if desired. Electroformed ducts are shown in Fig. 8, and another part made in this manner may be seen in Fig. 9, together with a similar part fabricated by other means.

Unusual Set-Ups for

Immediate Demands for Increased Production have Necessitated the Development of Unique Fixtures and Machining Set-Ups for Manufacturing Thunderjet Parts with Existing Equipment

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Machining Thunderjet Parts

GREATLY increased demands for Thunderjets—Republic Aviation Corporation's sleek jet-propelled successor to the famous Thunderbolt fighting plane—have required full productive capacity from existing manufacturing equipment at the company's plant in Farmingdale, N. Y. Tool engineers have been called upon to devise unusual fixtures and machining methods to speed the output of jet fighter parts from conventional machine tools. Some outstanding examples of the tooling that has been designed to meet production requirements will be described in this article.

Cast aluminum supports for the muzzles of 0.50-caliber machine guns—four of which are mounted in the nose of each Thunderjet—are difficult parts to machine. A compound contour must be produced on these gun mount castings so that they will accurately fit the external surface of the airplane nose. Transversely, the periphery of the support forms a radius of approximately 17 inches, while longitudinally, the contour forms radii varying from about 16 to 18 inches.

Since an engine or gap lathe of sufficient capacity was not available for this operation, it was necessary to design the special milling machine fixture and tooling set-up seen in the heading illustration. Nine of the cast aluminum gun mounts are turned simultaneously by clamping the work-pieces to two large-diameter faceplates that are fastened to the horizontal spindle of the machine. Pins projecting from the faceplates enter previously drilled holes in the castings for location purposes. A Kearney & Trecker No. 4 plain horizontal milling machine is employed for the operation.

Mounted near the right-hand end of the milling machine table is a fixture that holds the cutting tool at the correct height for turning by means of a riser block. The tool-holder (a conventional lathe toolpost) slides in an arc controlled by a track machined in a plate fastened to the top of the riser block, as seen in Fig. 1. Retaining straps confine the tool-holder to the track during its travel, which is accomplished by means of a manually rotated screw. The work-pieces are revolved at 27 R.P.M., while the single-point carbide-tipped tool is advanced into the work to remove 5/16 inch of stock during a roughing cut and 1/16 inch in a finishing operation. About forty-five minutes is required to load, complete both cuts, and unload the nine castings.

After the contour turning has been performed, the cast aluminum gun mounts are bored in another precision machining operation. The interrupted bores, 2.2385 inches in diameter by 12 inches long, must be held to a tolerance of $\pm$ 0.0005 inch. As a precision boring machine or horizontal boring mill was not available for this operation, it was performed on a Monarch 22-inch lathe by means of the set-up seen in Figs. 2 and 3. The work is held in a special fixture mounted on the lathe carriage in place of the compound tool-rest, while the boring-bar is rotated by a collet held on the lathe headstock, and is supported on the tailstock center. Further support is provided for the boring-bar by steady-rests at both back and front of the work-holding fixture.

Accurate location of the aluminum casting is obtained in the same way as for contour turning on the milling machine, dowel-pins being

Fig. 1. Tool-holder slides in an arc controlled by a curved track to produce a compound contour on the castings

provided in the end plates of the fixture that enter previously drilled holes in the work.

Two cuts are required to complete the boring operation. In rough-boring, the single-point carbide-tipped tool bit, which is held in the bar by means of a set-screw, is rotated at 150 R.P.M., while the carriage and work are fed at a rate of 0.005 inch per revolution. From 3/16 to 1/4 inch of stock is removed from the bore diameter in this cut. In finishing, approximately 0.020 inch of stock is removed, with the boring-bar rotating at 400 R.P.M. and the work fed at 0.003 inch per revolution.

Spherical sections for bushing assemblies used in the Thunderjet are machined from steel bar stock on Warner & Swasey No. 5 turret lathes, with the set-up shown in Fig. 4. The spherical or ball-turning attachment is secured to the back of the turret lathe cross-slide. Mounted on pivot-pins at the top and bottom of this attachment is

Fig. 2. Precision boring of the cast aluminum gun mount is done on a lathe, with the work-holding fixture mounted on cross-slide

Fig. 3. The boring-bar is supported by a collet mounted on lathe headstock, two steadyrests on the fixture, and the tailstock center

a semicircular casting on which the single-point tool is mounted. The tool is swung through the desired arc by means of a lever pinned to the lathe turret. The arc through which the tool travels is, of course, determined by the length of the turret stroke. Also, the distance from the center of the bar stock to the point of the cutting tool, which can be varied by feeding the cross-slide, equals the radius of the sphere to be generated. Balls or spherical sections varying from practically 0 to about 5 inches in diameter can be machined with this set-up.

On the particular part shown, a spherical diameter of 2.1245 inches is produced, the size being maintained within $\pm$ 0.0005 inch. Also, the required smooth surface finish of not more than 30 micro-inches r.m.s. is easily obtained without the need of a subsequent grinding operation. Starting with a 2 1/4-inch diameter bar, the 1 13/16-inch wide spherical section can be

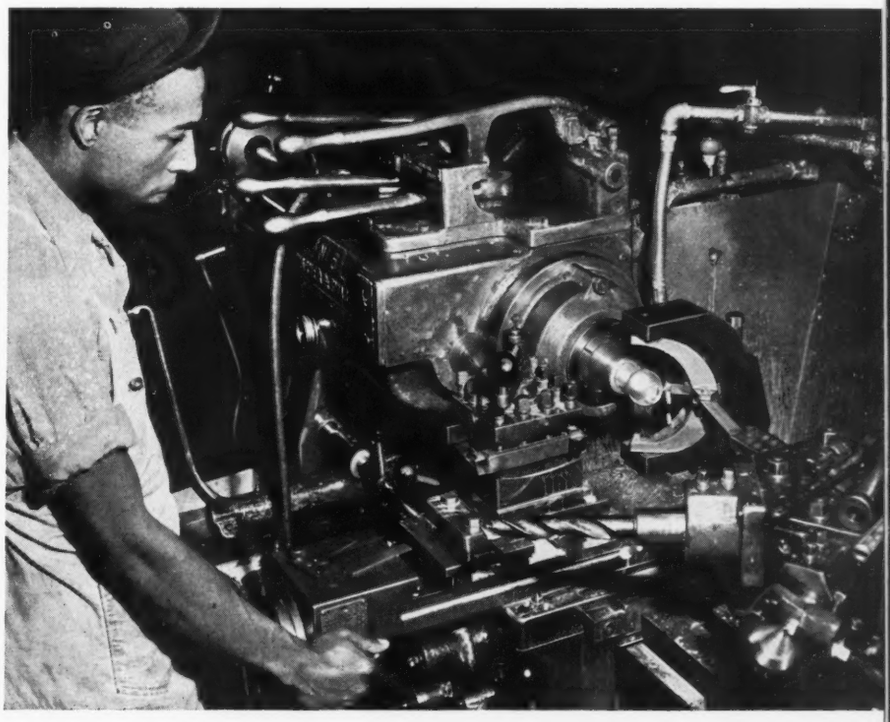


Fig. 4. Ball-turning attachment, mounted on the rear of the cross-slide, is lever-actuated by the power-fed turret of the lathe

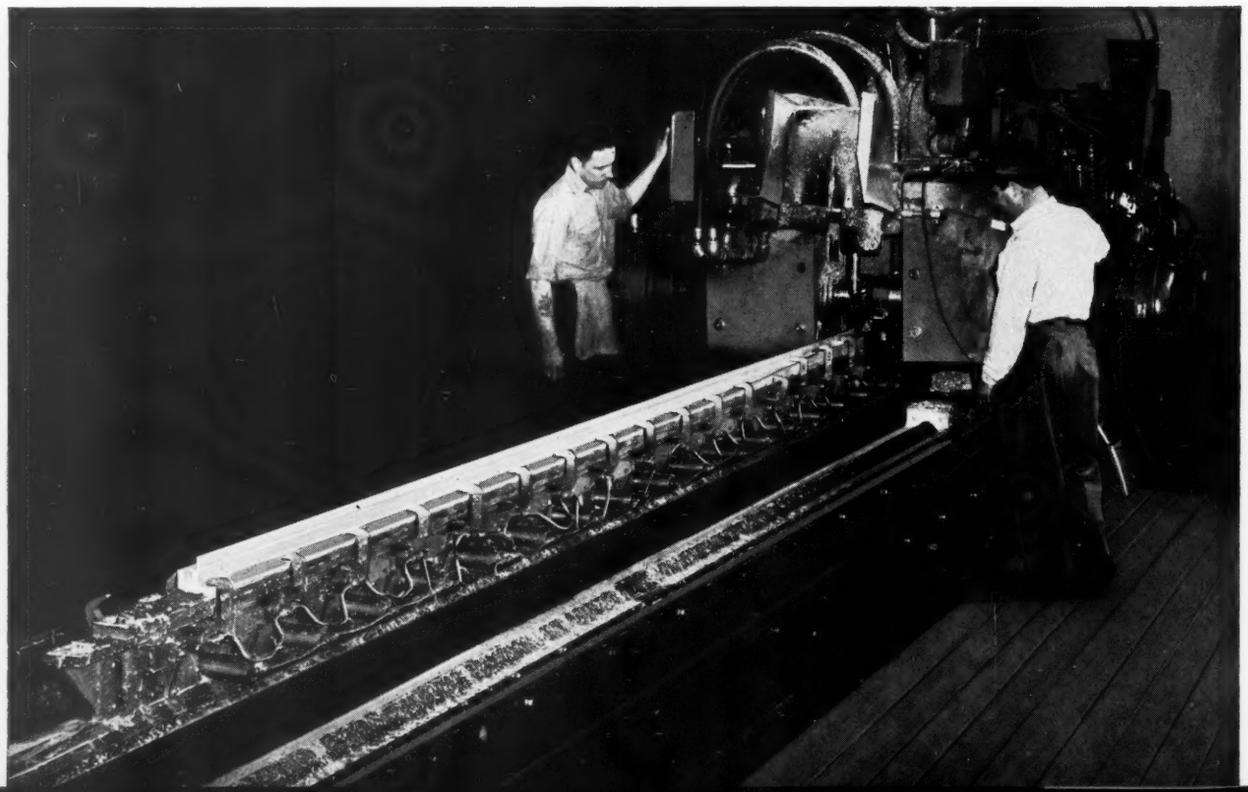
Fig. 5. A round tool-holder, swiveled by means of a hand-lever, is mounted on compound rest for performing spherical boring operations

completed in about three minutes. The lathe turret is power-fed at the rate of 0.012 inch per revolution, with the work rotating at 367 R.P.M. Stock removal, on the diameter, varies from approximately 0.010 to 1/4 inch at different points on the spherical surface of the work.

A similar set-up for spherical boring operations is shown in Fig. 5. The compound rest on the Monarch lathe used for this operation is equipped with a round tool-holder, which is rotated by means of a hand-operated lever. This lever fits into notches around the edge of the holder. During the spherical boring operation, the lever is successively moved from notch to notch, so that it will not interfere with the end face of the work-piece. A rounded nose, of approximately 1/64 inch radius, is ground on the small high-speed steel tool bit.

Since the compound rest is set parallel with the axis of the work and the lathe spindle, and the cutting tool is set at the same height as the center of the work, the size of the spherical surface produced depends upon the distance of the cutting edge from the center of the tool-holder. This can be altered by changing the radial location of the tool in the holder, which is accomplished by simply loosening a set-screw and sliding the tool in or out. To produce the spherical bore shown, which is 2 7/8 inches in diameter, a hole 2 inches in diameter was first drilled in the end of the aluminum alloy bar. In the spherical boring operation, the work is rotated at 480

Fig. 6. Spar cap milling machine equipped with three individually actuated cutter-spindles by means of which variable profile cuts are taken on all three legs of an aluminum extrusion



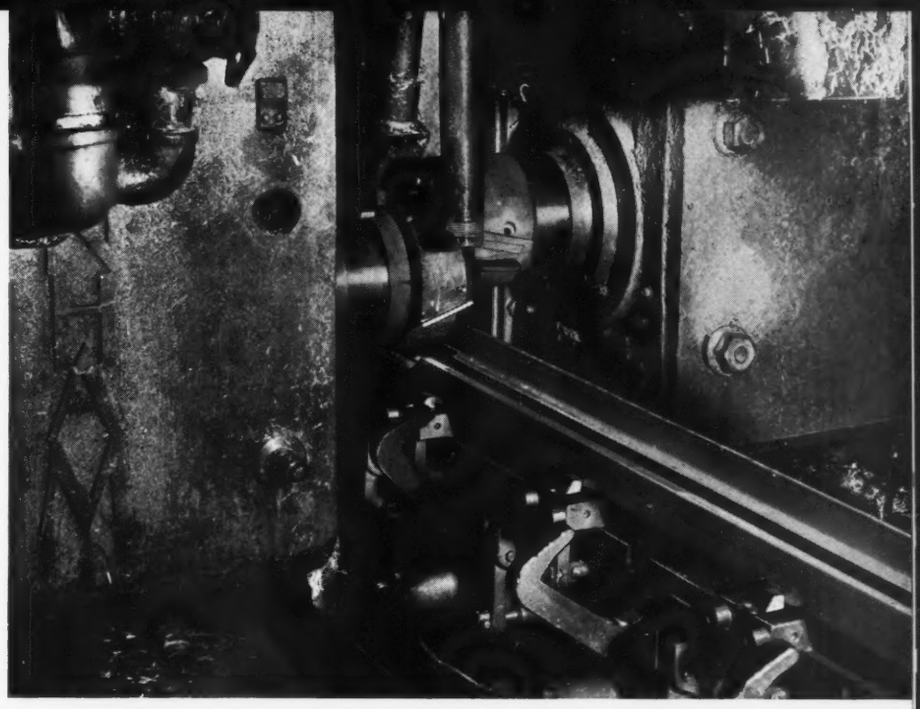


Fig. 7. Two of the three cutters employed on the spar cap milling machine seen in Fig. 6. Each cutter has two carbide-tipped blades

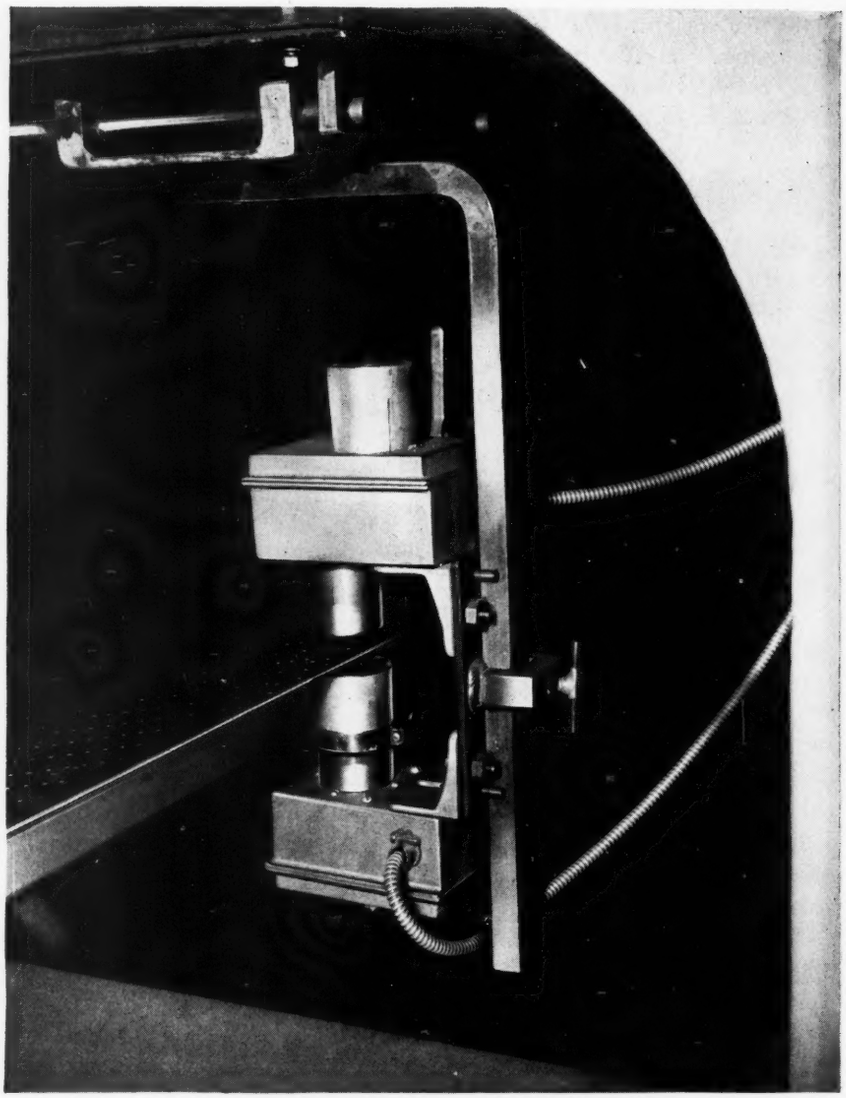
R.P.M., and from 0.060 to 0.100 inch of stock is removed per cut.

An unusual feature of the spar cap milling operation illustrated in Fig. 6 is the use of three spindles, two of which contour-mill the 75S-T aluminum alloy extrusion when the head is moving in one direction, while the third operates when the head is returning. The three-legged extrusion, which is 15 feet 9 inches long, is hydraulically clamped to the bed of the Farnham machine employed for this operation. A close-up view of two of the spindles is shown in Fig. 7. The left-hand spindle mills one leg and part of the center leg during the return stroke of the head. The right-hand spindle, and the third spindle seen on the opposite end of the head in Fig. 8, mill the opposite leg of the extrusion and the remaining portion of the center leg during the forward stroke of the milling head.

Each spindle is equipped with a carbide-tipped, two-bladed milling cutter, 6 1/2 inches in diameter, which is rotated at 3500 R.P.M. During the forward stroke, when two cutters are in contact with the work, the head travels at the rate of 100 inches per minute. On the return stroke, with a single tool cutting, the head travels at 150 inches per minute. The maximum depth of cut is approximately 1 1/2 inches, while the width of each cut is about 1/2 inch.

Each of the three spindles is operated independently, being raised or lowered hydraulically by means of rollers in contact with templates mounted horizontally along both sides of the machine. Individual and variable profile cuts can thus be taken on all three legs of the aluminum extrusion. This spar cap milling machine is also equipped with a chip conveyor that runs the full length of the machine below the bed.

Fig. 8. Third cutter on opposite end of milling head from that shown in Fig. 7. Part of the variable contours produced on the extrusion are shown



Electric eye unit used in connection with a template on "Drivmatic" drilling, countersinking, and riveting machine (right) for automatically controlling the spacing of rivets used to attach stringers to airplane skins

Electric Eye Accurately Locates Work

A Photo-Electric Cell is Employed for the Automatic Locating of Airplane Skins and Stringers beneath Drilling, Countersinking, and Riveting Unit of "Drivmatic" Riveting Machine

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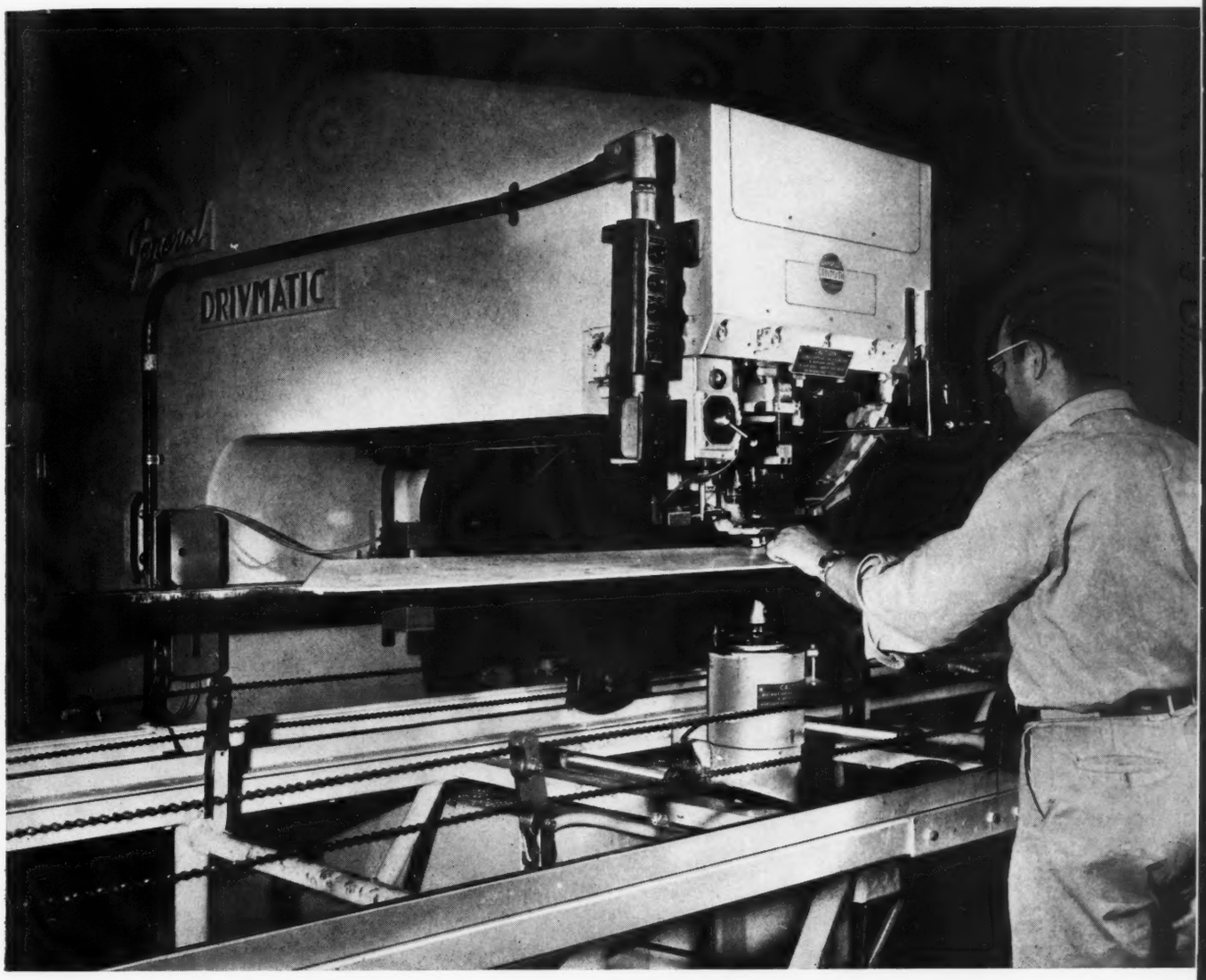
THE riveting of stringers to airframe skins has been greatly expedited in the Torrance, Calif., plant of North American Aviation, Inc., by providing means of automatically locating the work beneath the drilling, countersinking, and riveting unit of a General "Drivmatic" riveter for each successive operation. This automatic indexing method is effected by the use of a photo-electric cell attached to a slide which is mounted beneath the over-arm of the machine, and a drilled template at the back of the handling fixture on which the work is mounted. The entire indexing and riveting cycle is automatic, and is either automatically or selectively repeated, depending on the setting by the operator.

Small holes are spaced in parallel lines along



in Riveting Operations

a template plate to correspond with the rivet spacing in the skin and stringer assembly. However, the distances between the parallel rows on the template are much less than the distances between the corresponding rows of holes to be drilled in the work, so that a comparatively narrow template is required rather than one of the same width as the work. A close-up view of the photo-electric cell and of part of a typical template is shown in the heading illustration on page 192. The template plate is located on the fixture by registering dowel-holes in the template over dowel-pins on brackets that are attached to the fixture.

When light from the light source passes through a template hole and strikes the photo-electric cell, it operates a hydraulic control valve through relays, instantly stopping movement of the material-handling fixture and thereby locating the skin and stringer assembly in the exact location for drilling and countersinking a hole and for inserting and driving an aluminum-alloy rivet into the hole.

The lower anvil holds the work against the upper pressure foot during the operations. When the pressure is released at the end of a cycle, the hydraulic control valve is again actuated through relays, and the handling fixture and template are moved to the next rivet position. The work is moved during the period that the machine resets itself for the next cycle, which is less than one second. This brings the total riveting cycle time down to about three seconds.

The boxes in which the solenoid switches are

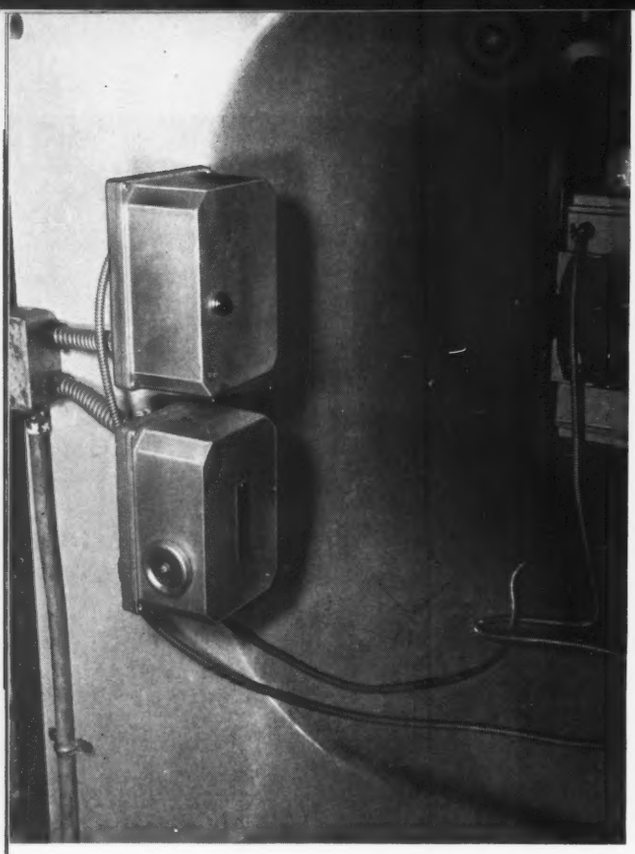


Fig. 1. Solenoid switch boxes on the column of the "Drivmatic," which cause the table to stop and start, respectively, prior to and following each operation

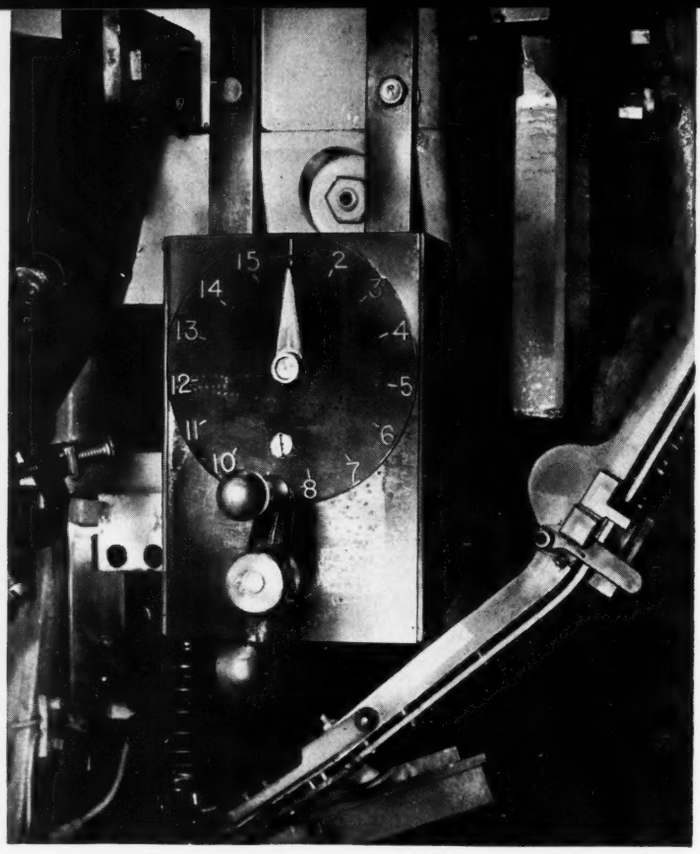
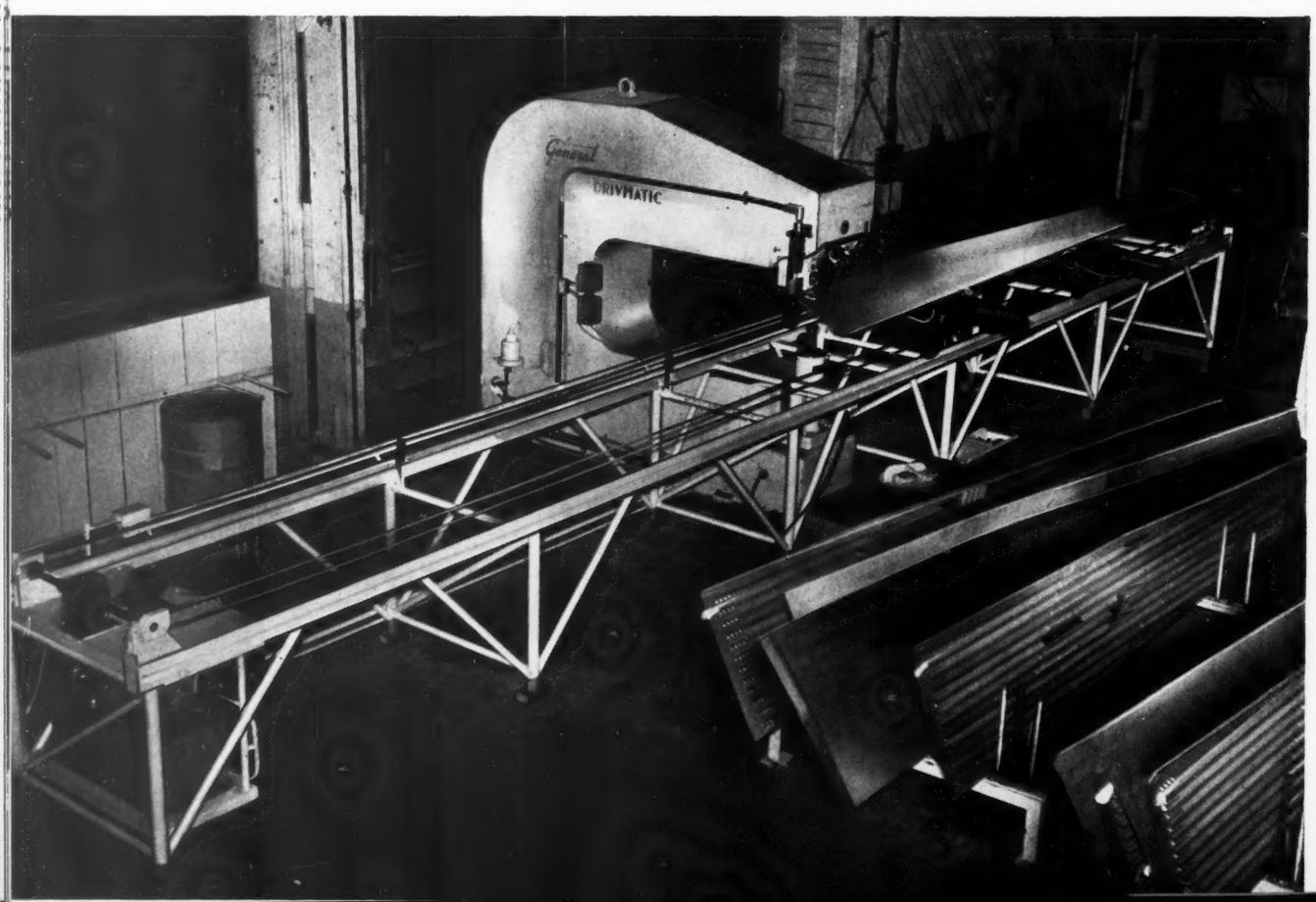


Fig. 2. Dial and lead-screw handle which facilitate in and out adjustment of the electric eye to correspond with crosswise adjustments of the work

Fig. 3. General view of the "Drivmatic" riveting machine equipped with an electric eye, showing typical riveted airplane skins in the foreground of the illustration



located are attached to one side of the machine column, as may be seen in Fig. 1. The practice is to drill holes and drive rivets to correspond with all the holes in a lengthwise row of the template. Then the work-table is indexed crosswise to position the work for the next row of rivets. The slide that carries the photo-electric cell is also adjusted at this time to bring the photo-electric cell in line with the next row of holes in the template plate whose lay-out pattern is to be reproduced on the work. This adjustment of the electric eye is facilitated by means of a dial at the front of the machine, which is shown in Fig. 2.

When the handle beneath this dial is turned, a lead-screw is revolved to feed the photo-electric slide forward or backward, depending upon the direction in which the handle is rotated. As the handle is turned, the indicator moves in a similar direction around the dial. The numerals on the dial correspond with the different hole patterns on the template.

The "Drivmatic" is operated in the normal manner. A clamping pressure of 700 pounds is exerted to hold the work-pieces securely together during the drilling, countersinking, and riveting. As stated previously, the cycle repetition may be either automatic or selective. In either case, the operation is controlled by foot-operated switches. With the electric eye and handling mechanism, this riveting machine can drive up to twenty-two rivets per minute.

As all rivets are driven with the same amount of pressure, rivet rejection amounts to less than 1 per cent. In hand-riveting, rejections have generally run from 12 to 13 per cent. Also, with this machine 99 per cent of rivet-head milling is eliminated, whereas with hand-riveting, it is necessary to mill 100 per cent of the heads.

Another novel feature of this machine is the special hopper provided for the rivets, which is mounted on the right-hand side of the column, and contains dry ice to prevent the heat-treated aluminum alloy rivets from aging too fast.

North American B-45
"Tornado" jet bomber

Big Machines Build

Typical Machine Tools Installed in a Seventeen Million Dollar Equipment Purchasing Program

By
CHARLES O. HERB

BOMBERS and transport planes of huge size have long been a specialty of the Boeing Airplane Co., Seattle, Wash. When this company first built the Pan-American Flying Boats—which were larger than the ships of Columbus—it was believed that the utlimate had been attained in the size of airplanes. Then came the Flying Fortresses of early World War II days, and later the Superfortresses with wing spreads of more than 141 feet and over-all lengths greater than 98 feet.

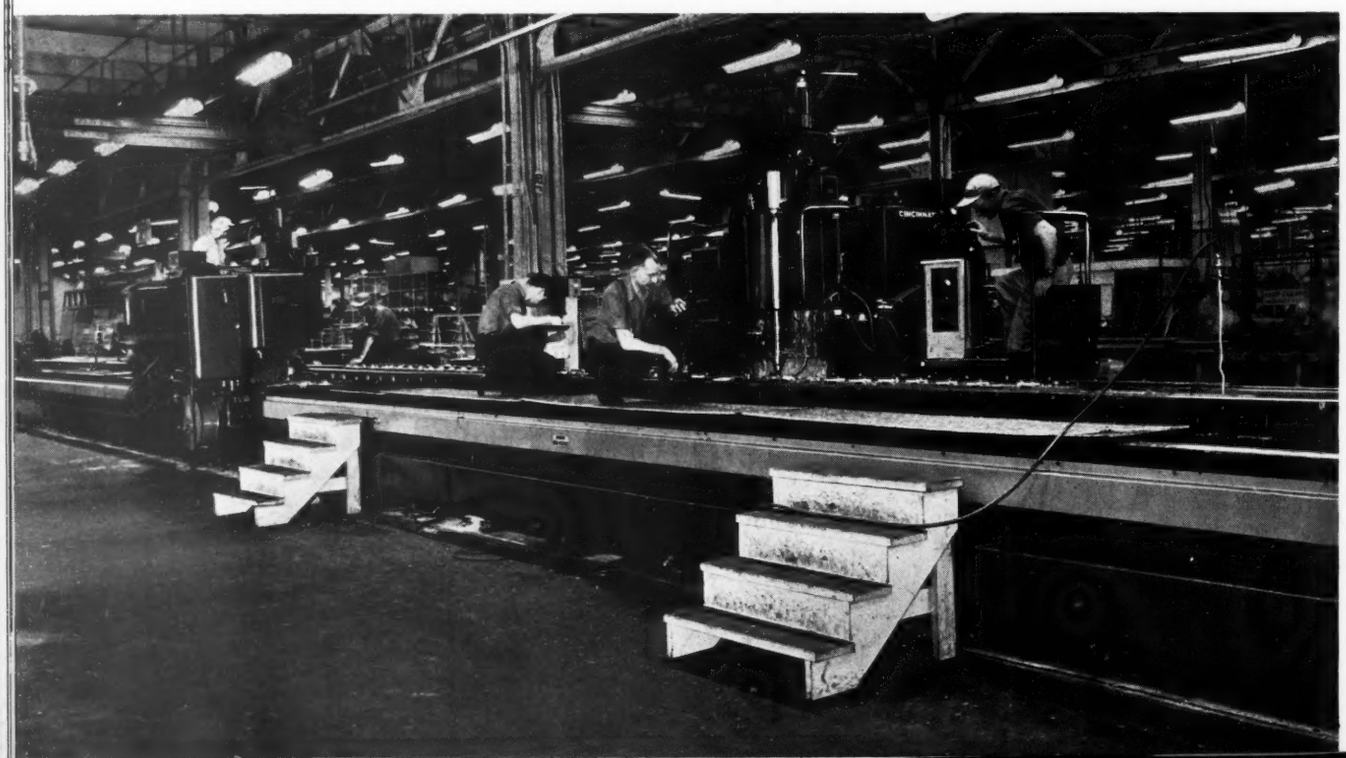
Still larger bombers have been produced since the war, and now the company has embarked on a program of building XB-52 bombers—a multiple-jet heavy-bombardment type. This type plane will constitute one of our most potent weapons, and for this reason details of its unique construction are closely guarded.

Machine tools of a size not associated until recently with aircraft production are required in building huge bombers. The Boeing Airplane Co. spent almost seven million dollars in 1950 for the replacement of machinery and the installation of new equipment to meet expanded requirements. This year the concern is spending ten million dollars—mostly for large machines, tooling, heat-treating facilities, etc.—to prepare for the production of the world's largest bombers, as well as standard types of planes. Operations on some of the recently installed machines will be described in the following.

A milling machine with two vertical-spindle heads and with a bed 92 feet long, which will soon be extended to 130 feet, is illustrated in Fig. 1. This machine, built by the Cincinnati Milling Machine Co., is designed for milling either long spars or short spar members in multiple arranged one after the other along the table.

As can be seen, the milling heads are mounted on opposite sides of the bed, and are equipped with electronic controls for moving the cutter-slides in and out or up and down as the follower

Fig. 1. Cincinnati milling machine used for milling either the long spars of huge present-day planes or short spar members arranged in multiple on the long table



Boeing Bombers

Boeing B-47A Stratojet bomber

of a tracing mechanism moves along a template. With this arrangement, contours in vertical and horizontal planes and at angles between the two planes can be milled within a tolerance of ± 0.005 inch. Fig. 2 shows a close-up view of one of the cutter-heads engaged in a typical operation. The follower of the tracing unit and the template may be seen at the right.

Since the machine is of open-side design, wing skins of any width can also be handled. Cutters up to 6 inches in diameter may be used. The cutter-spindles can be run at speeds up to 3500 R.P.M., but modifications have been planned to provide spindle speeds up to 10,000 R.P.M. Cuts are taken on aluminum spars at speeds up to 300 inches per minute. Automatic conveyors in the machine bed carry the chips to removal elevators at opposite ends of the bed.

An Onsrud spar milling machine with a bed 90 feet long, which is being extended to 120 feet, is illustrated in Fig. 3. This machine is provided with four milling heads on one carriage, two of the heads having horizontal spindles and the other two vertical spindles. A close-up view of the vertical-spindle heads is shown in Fig. 4. One of the followers of the individual tracing mechanisms may be seen directly in back of the left-hand cutter in engagement with the flat plate template. Each spindle head is provided with an individual motor drive. The right-hand vertical-spindle head can be tilted for taking angular cuts. Templates control all cutter movements in the conventional manner for machining the work to the desired contour.

Long spars or short spar members in multiple can also be handled on this machine. The heads can be conveniently adjusted up and down or sidewise in both directions through the operation of valves. This machine is also equipped with screw conveyors in the bed for quick disposal of the rapidly formed aluminum chips.

Another of the new machines is the Cincinnati horizontal Hydro-Tel shown in Figs. 5 and 6, which is employed for the rapid milling of irregular shapes in forgings or from solid billets. The work is mounted on the large angle-plate, with the master above it. The part shown in the illustration is smaller than is normally handled with this equipment. Hydraulic controls cause the cutter to follow closely the movements of the tracer stylus. The machine table with the angle-plate moves back and forth along the bed as required, and the cutter-head moves up and down the column.

This machine is large enough to handle big bulkhead sections. The angle-plate shown on the machine measures about 6 by 8 feet, but the capacity can be increased considerably by the

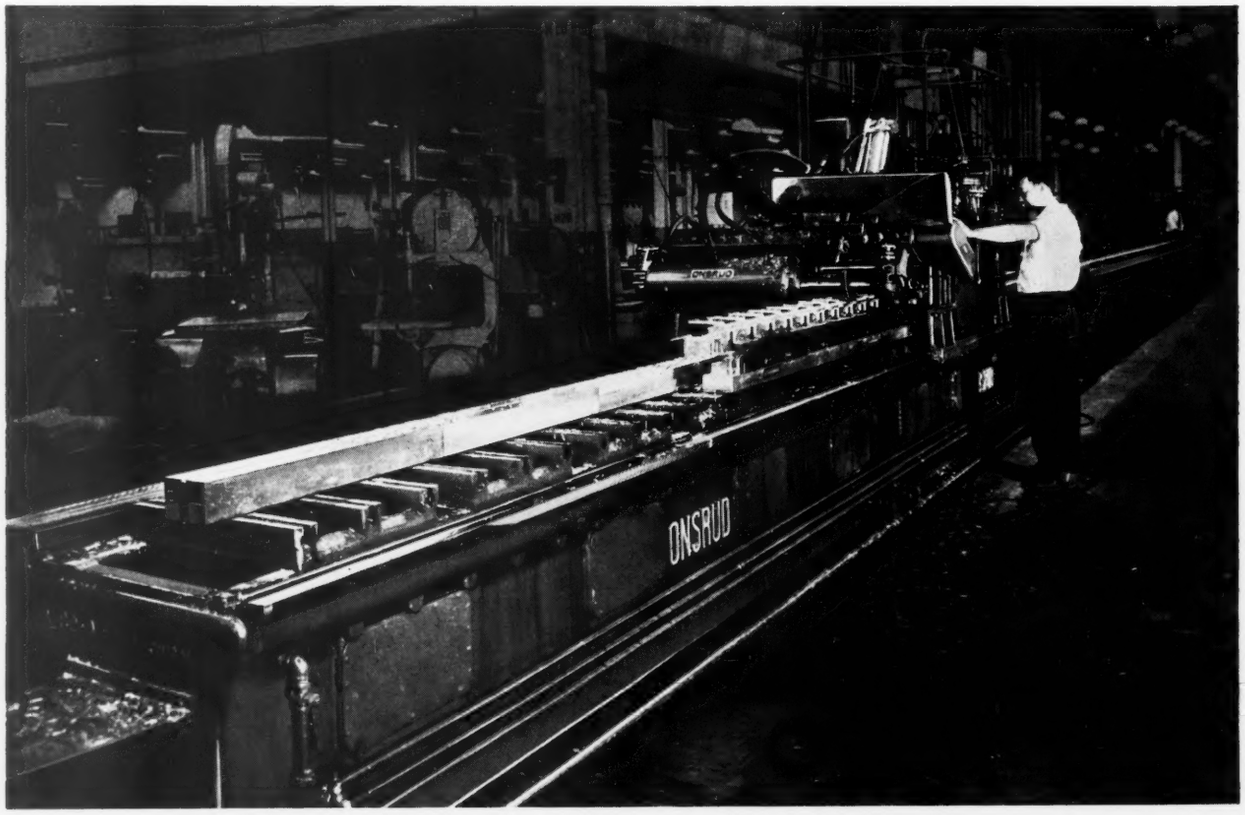
Fig. 2. Close-up view of one of the heads with hydraulic tracer control provided on the large Cincinnati spar milling machine

Fig. 3. (Below) Onsrud spar milling machine designed for handling the spar members of today's huge bombers and transport planes

use of extensions. The cutter-spindle of this machine can be run at speeds up to 7000 R.P.M., with provision for higher speeds. Accuracy of the work is of prime importance in all operations performed with this equipment.

A big Pratt & Whitney jig boring machine, Fig. 7, has been installed for handling large plane members, as well as dies, jigs, and fixtures. A close-up view of a typical operation is shown in Fig. 8. Tooling devices are ordinarily held to dimensional tolerances of $\pm$ 0.0005 inch; however, the airplane members machined on this jig borer are not held to such close tolerances.

The table of the machine measures 6 by 3 feet. There is a panel control for the spindle motor, spindle clutch and brake, spindle head and clamp, carriage traverse, and table traverse. This machine employs a new measuring system incorporating certain features of the "Electrolimit" gaging principle. Basic 1-inch spacing is ob-



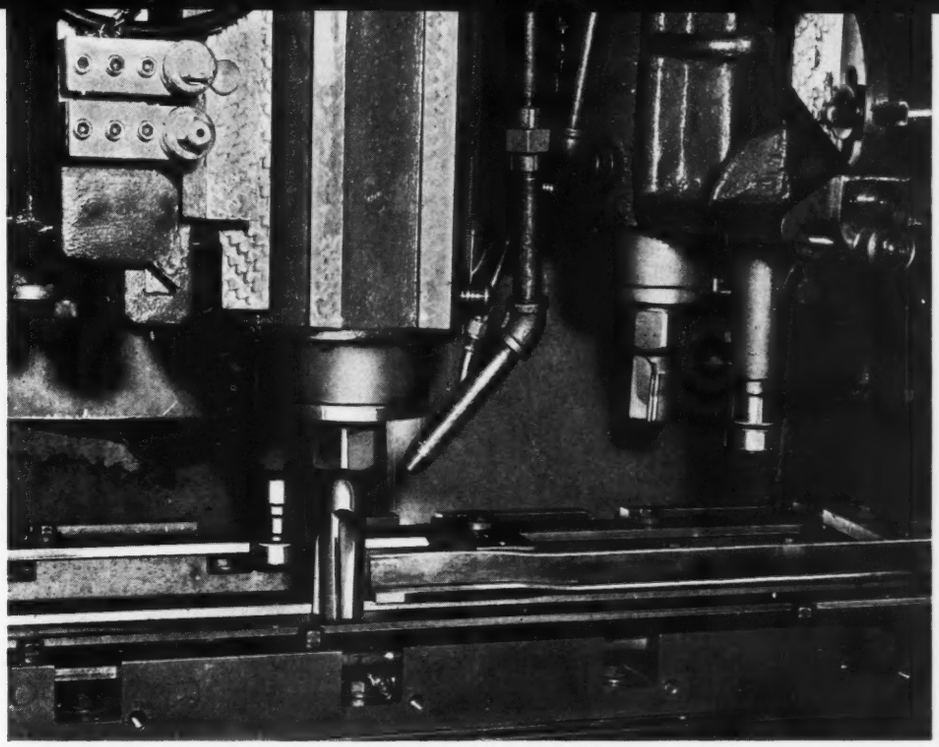


Fig. 4. Close-up view of the vertical cutter-spindles on the Onsrud spar milling machines. One of the followers of the individual tracing mechanisms is seen in back of the left-hand cutter

tained from a master measuring bar by electrical means without making physical contact with the bar. The master bar has rectangular projections that are calibrated so that the distance between the magnetic centers of adjacent projections is 1 inch within a tolerance of twenty-millionths inch accumulated error in the full length of the bar.

Two of the master bars are built into the machine at right angles with each other. The one under the table is used for positioning the table longitudinally, while the other, on the under side

Fig. 5. Large horizontal Cincinnati Hydro-Tel which is used for milling aircraft parts to irregular contours

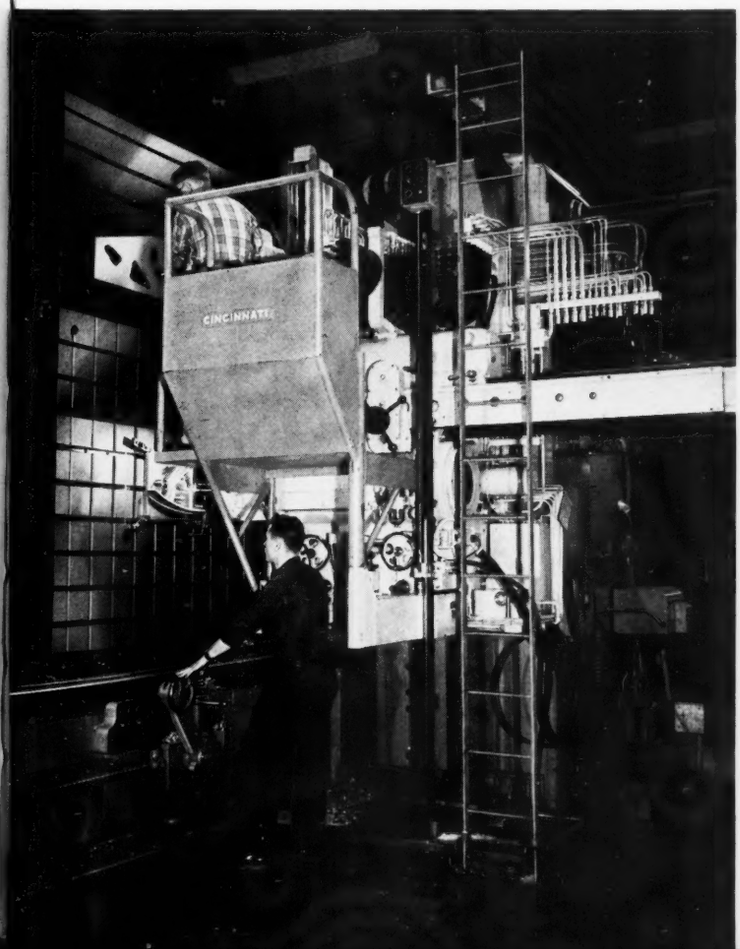


Fig. 6. Close-up view of a comparatively small job on Hydro-Tel, showing arrangement of work and master

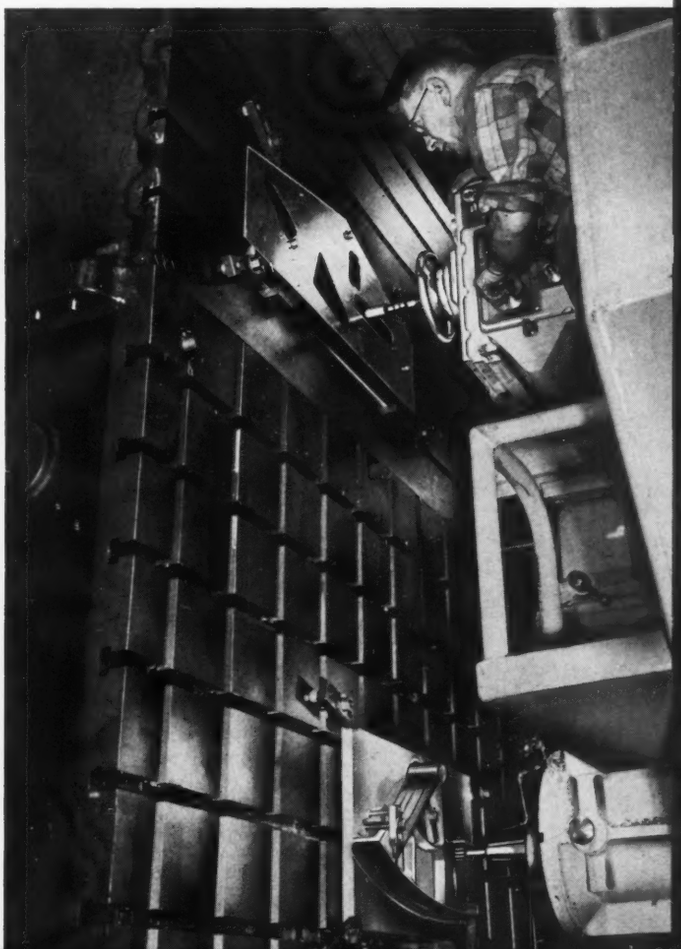


Fig. 7. Huge Pratt & Whitney jig borer recently installed in the Boeing plant for performing a variety of operations on both work and tooling

of the carriage, is employed for positioning the table transversely.

The basic 1-inch spacing is subdivided by positioning an electromagnetic head between any two projections on the master bar with a high-precision micrometer screw. A micrometer barrel, 4 1/2 inches in diameter, with wide spaced graduations permits easy reading for direct settings to 0.0001 inch.

Rolled and extruded sections of aluminum alloy and stainless steel are stretched to required shapes by the 50-ton Cyril Bath Roto-Former shown in Fig. 9. Channels, T-sections, angle sections, L-sections, etc., are easily handled through the use of forming blocks designed to suit. Wood filler blocks, assembled in long units by means of a special rope, are placed in the work sections to prevent wrinkling when the operation is performed. Two of these filler blocks may be seen at the right in Fig. 10 in position on a typical extrusion.

The machine consists primarily of a long bed, on which a turret is mounted which carries the gripping head seen in Fig. 10, and a rotary table, on which a second gripping head is held, as clearly seen in Fig. 9. At the beginning of an operation, the straight work section is clamped at the ends in the two gripping heads by the hydraulically operated jaws, as seen in this illustration. Then as the rotary table swings the gripping head mounted on it in a circular path to stretch the work around the form block, as shown in Fig. 11, the turret swivels to permit the work-piece to assume the desired shape. At the same time, the ram that holds the slide gripping head moves along its column. The movement of the second gripping head is hydraulically controlled, so that the work-piece may be stretched at a predetermined rate. This is accomplished by exerting a suitable pressure on the hydraulic cylinder in back of the gripping head ram.

The table gripping head can be placed in various positions on the table to suit the particular job being handled. Both gripping heads can be adjusted to the required heights.

Fig. 8. Close-up view of a typical set-up on the jig boring machine, which is equipped with new "Electrolimit" measuring system

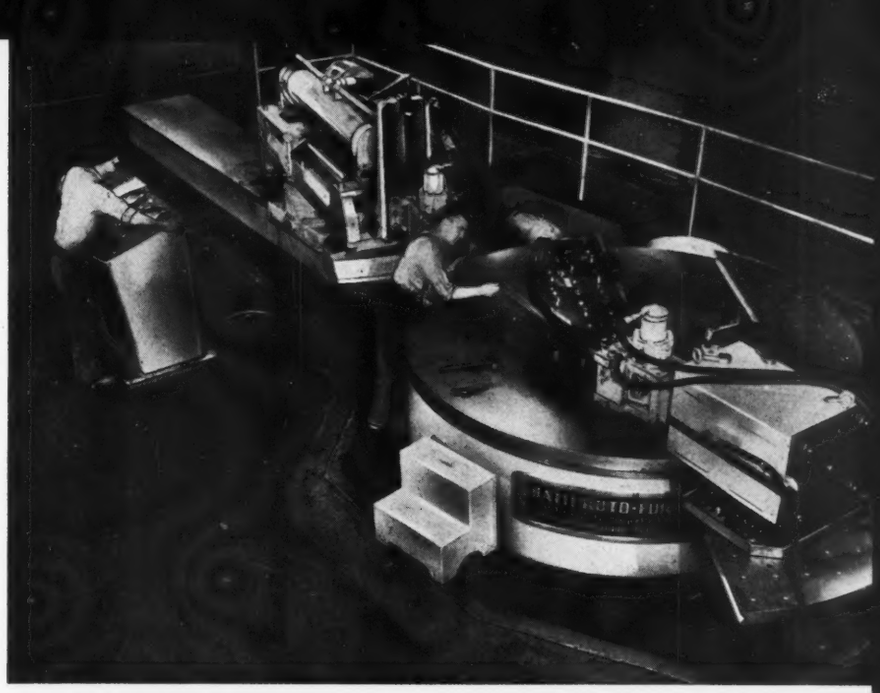


Fig. 9. General view of a Cyril Bath Roto-Former, showing the manner of loading the work for the performance of a stretch-forming operation

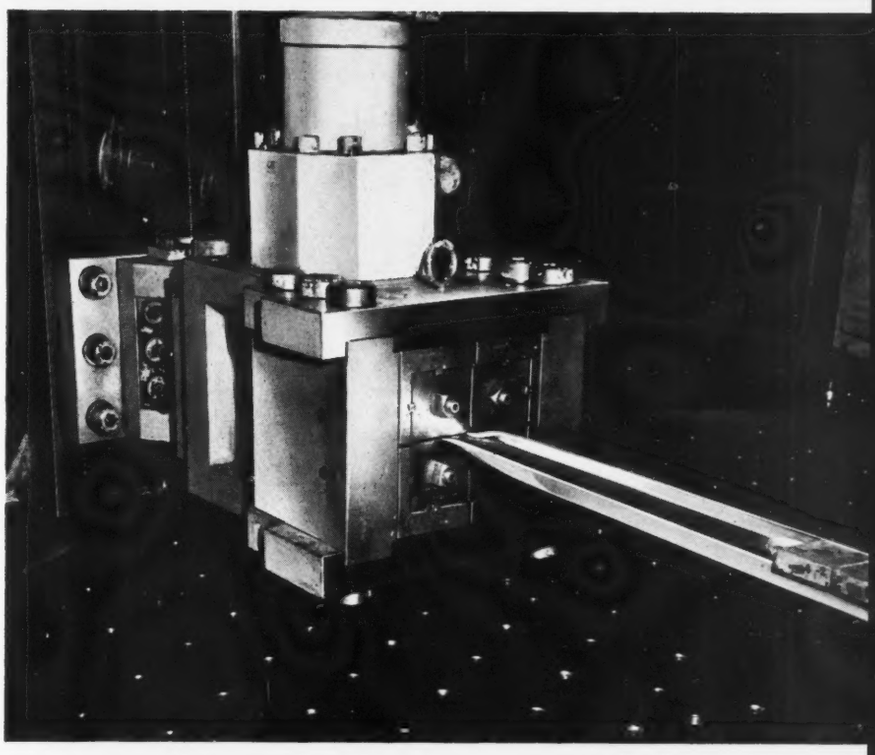


Fig. 10. Close-up view of gripping head mounted on the Roto-Former sliding unit. Note the wooden filler blocks at the right placed in the work section to prevent wrinkling

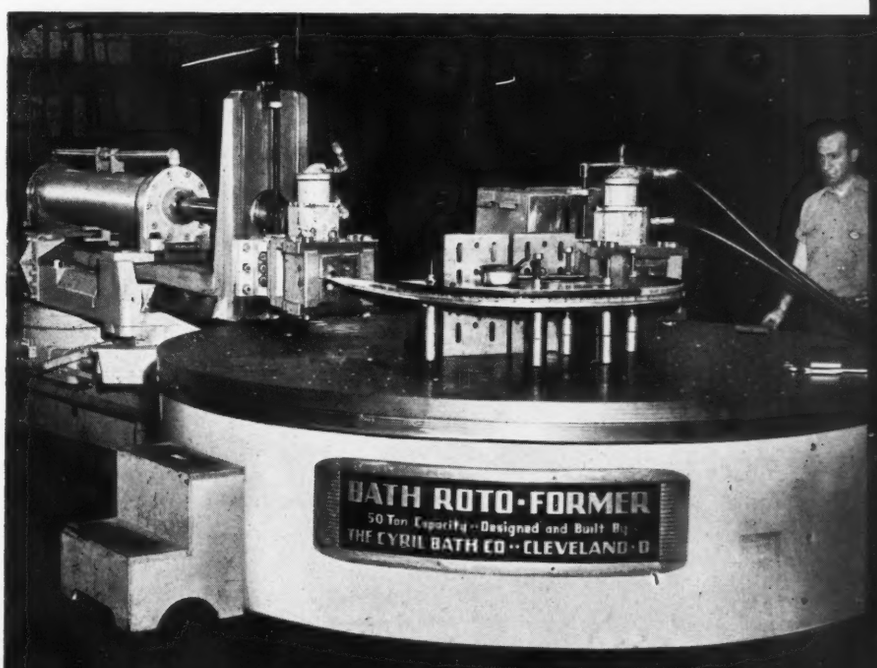
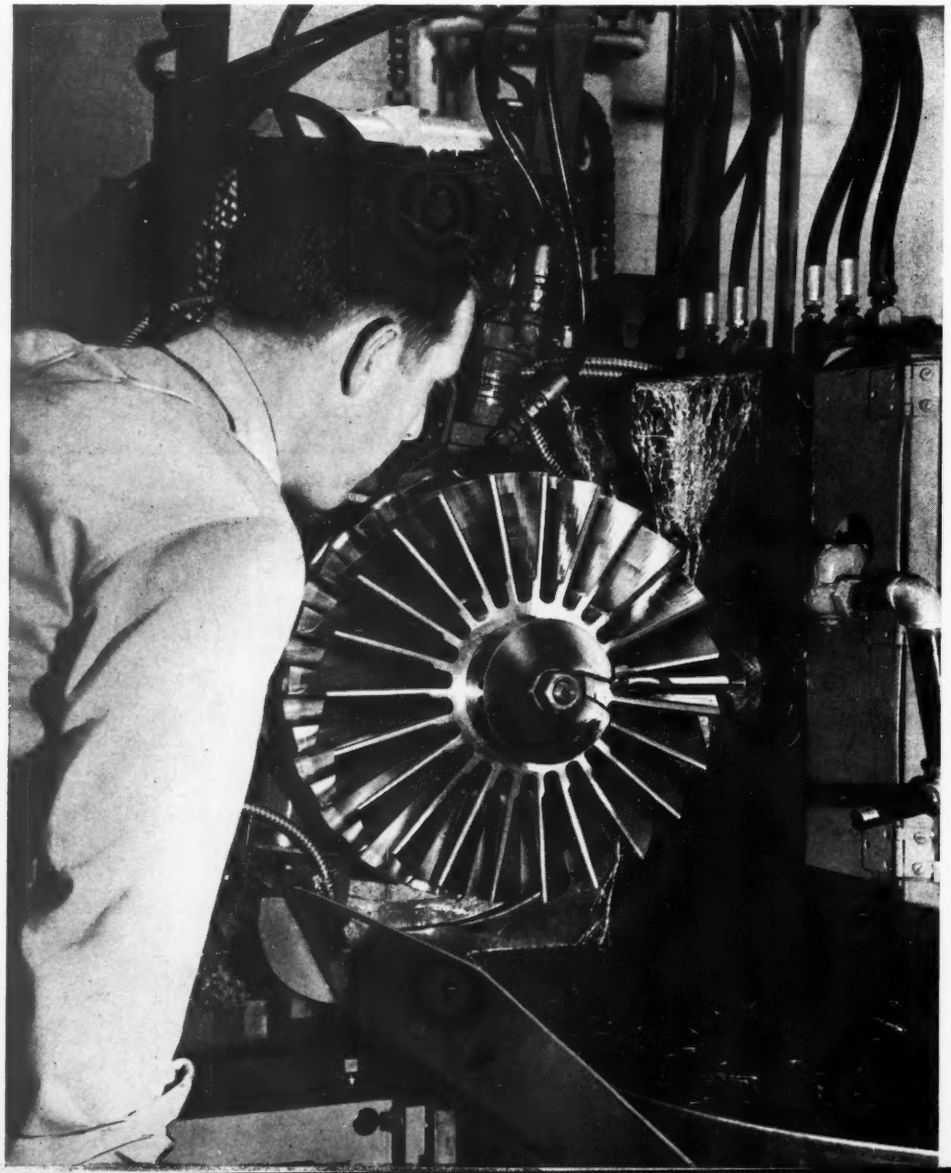


Fig. 11. The completion of the stretch-forming operation performed on the Roto-Former, showing the extrusion wrapped around the forming block

Three-Dimensional Machining of Allison Jet-Engine Inducers

SUCH fast fighters as the Grumman F9F-3 Panther, the Lockheed F-80 Shooting Star, and the Convair XF-92 are powered by the Allison J33 engine. This engine is rated at 5400 pounds thrust with water and alcohol injection, and is capable of developing the equivalent of 10,000 H.P. This jet engine has a single-stage, axial-flow type gas turbine, and is distinguished by a double-entry centrifugal compressor.

Extremely accurate, high quality parts must be produced to withstand the high speeds, elevated temperatures, and tremendous stresses encountered in such engines. For example, the compressor of the Allison J33-A-16 engine rotates at 11,750 R.P.M., and forces 79 pounds of air per second—compressed in the ratio of 4.1 to 1—into the combustion chambers. For efficient compression, turbulence in the air must be kept at a minimum and the compressor parts must be accurately machined to a smooth finish.



Semi-finish-forming the concave contour on the vanes of jet-engine inducers, following gashing operation seen in Fig. 3

By
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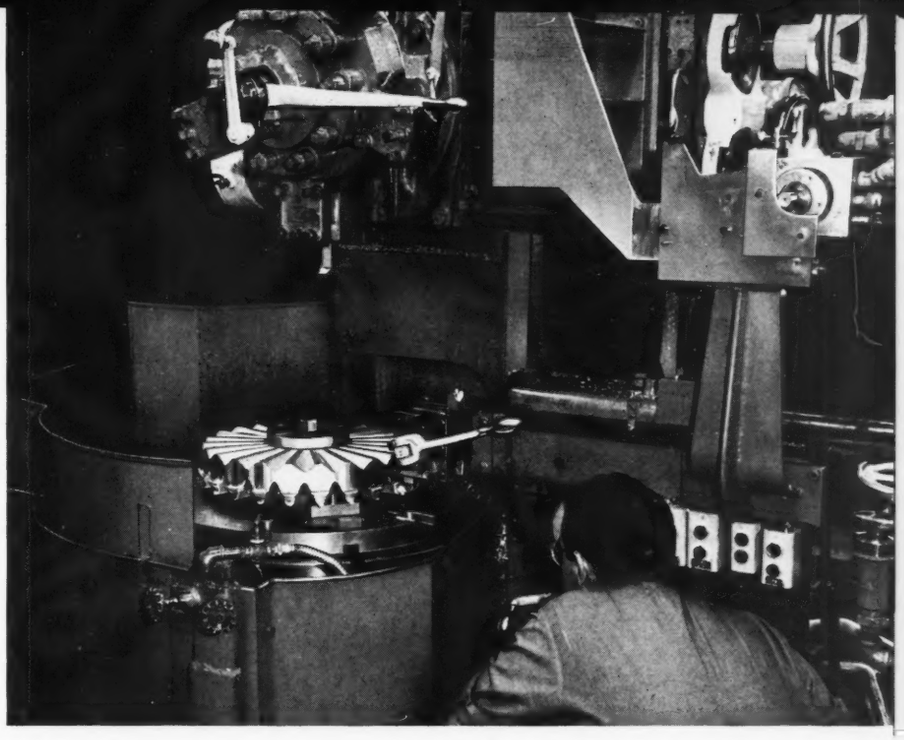


Fig. 1. A vertical turret lathe equipped with an automatic, tracer-duplicating attachment is used to finish-turn, form the periphery, finish-face, and chamfer inducers

Important components of the jet-engine compressor are the vaned inducers which form the inlet portions of the double-entry compressor impeller and are especially designed to dampen vibration. One inducer is mounted on each side of the impeller, and their rotating guide vanes must be accurately blended with those of the impeller. Surface finish on the inducer vanes must not exceed 32 micro-inches r.m.s., and the twenty-three vanes—the number that has been found to be the least likely to set up vibrations when the air contacts the vanes—must be equally spaced within plus or minus 0.0025 inch. Machining operations on this critical part are described in the following.

Compressor inducers are made from forgings of 25S aluminum alloy containing from 3.9 to 5.0 per cent copper, 0.5 to 1.2 per cent silicon, 0.4 to 1.2 per cent manganese, and maximum contents of 1.0 per cent iron, 0.05 per cent magnesium, 0.10 per cent chromium, 0.25 per cent zinc, and 0.15 per cent titanium. The "finger" forgings are approximately 20 inches in diameter by 3 1/2 inches wide, and weigh 97 pounds. About 70 1/2 pounds of aluminum is removed from each forging, the finished inducer weighing only 26 1/2 pounds.

In the first machining operation, the aluminum alloy forgings are faced, turned, bored, and chamfered on a 36-inch Bullard vertical turret lathe. The forging is located on the smaller diameter face, and clamped on the periphery by means of a three-jaw chuck. A second Bullard vertical turret lathe, Fig. 1, is then employed to finish-turn, form the periphery, finish-face, and chamfer the forging. In this operation, the work rests on positioning pads with locating fingers projecting into the spaces between several of the fingers on the forging, and is clamped by means of a C-washer which contacts the upper face.

The second vertical turret lathe is equipped with a Turchan automatic, tracer-duplicating attachment, seen at the upper right. Horizontal movement of the round-nosed tool used to form the periphery is hydraulically controlled as the tool is fed mechanically down past the work. A tracer roll, seen in contact with the template, controls the amount of oil flowing through a metering valve into the cylinder that moves this tool horizontally. The work is rotated at 200 R.P.M., and the various tools are fed at the rate of 2 inches per minute. Approximately one-half hour is required to complete each forging.

The difficult and critical operation of producing the three-dimensional vane contours on the inducer forgings is automatically accomplished on standard Kearney & Trecker 4K horizontal milling machines, seen in Fig. 2, that have been modified for this operation by the H & A Tool Co. A total of eight such machines is employed, four for the rear inducers and four for the front inducers. The table on each of the knee type milling machines is equipped with a cam-actuated work-holding fixture that is hydraulically and electrically controlled. A weighted stabilizer counterbalances the combined load of the large fixture and work on the end of the table, thus preventing misalignment.

The finished bore of the inducer forging is gripped by an expanding arbor sleeve, mounted on the tapered spindle projecting from the fixture. Radial location is obtained by a dowel-pin, which enters a previously drilled and reamed hole near the center of the forgings. A C-washer and nut on the end of the spindle hold the workpiece against a radially grooved faceplate on the

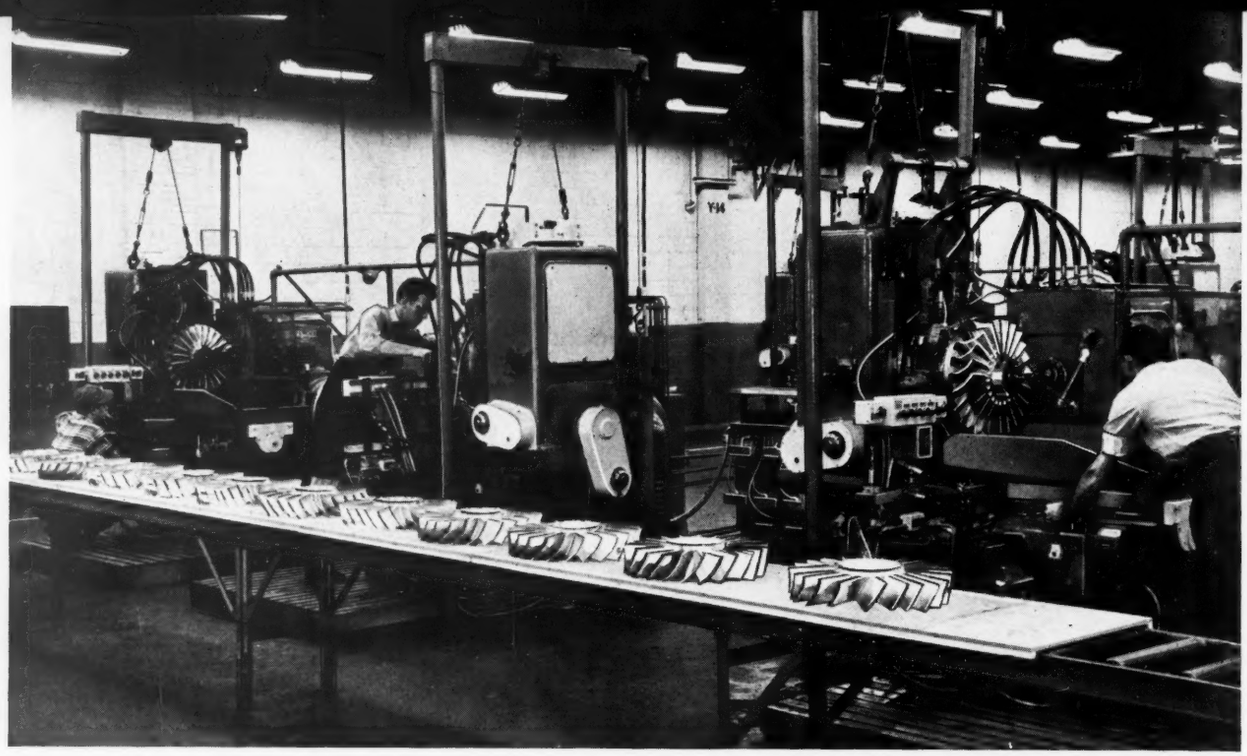
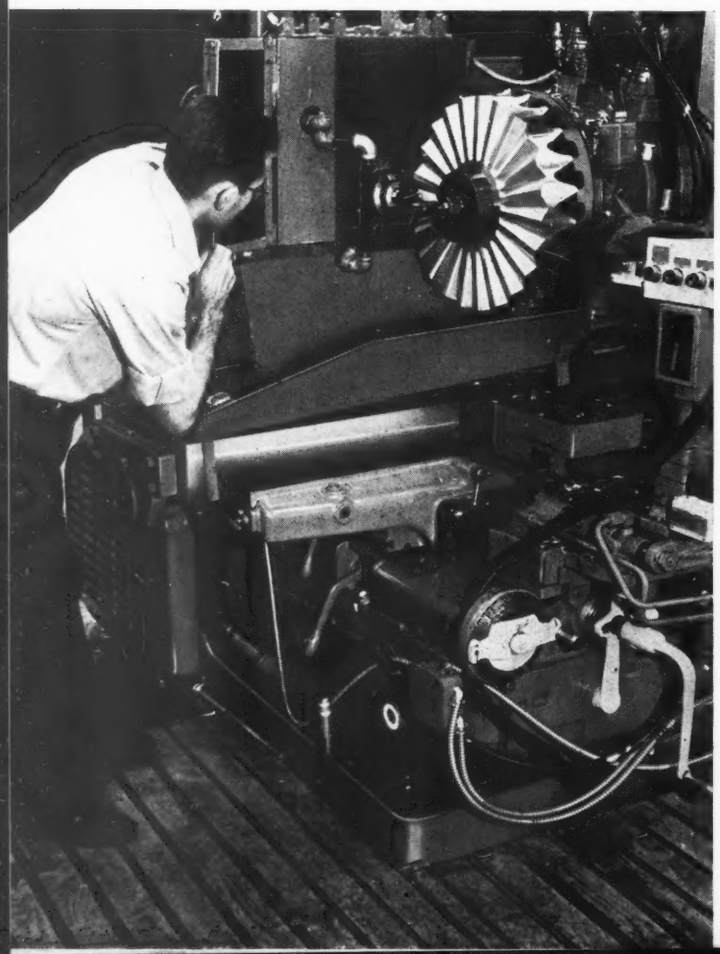


Fig. 2. Forged aluminum inducers are gashed and the contour on twenty-three vanes is formed on automatic cycling, specially equipped milling machines

fixture. The grooves on the faceplate provide clearance for the milling cutter.

The table on which the fixture and work are mounted moves in toward the cutter, then longitudinally past the cutter, out away from the cutter, and finally returns rapidly to its starting position. As the work is fed slowly past the fixed center line of the cutter, it is swung through various angles by cams to generate the desired contour on the vane being machined. While longitudinal movement of the table is effected by a conventional mechanical drive, transverse motions are hydraulically actuated and controlled by cams.



On the first machine of this group, Fig. 3, the inducer forging is gashed—the material between the forged fingers being cut through to roughly form the vanes—and the concave contour of the vanes is semi-finish-formed. During each of these operations, the inducer is automatically indexed twenty-three times. Indexing is accomplished by means of hydraulic cylinders, and limit switches electrically control the cutting cycle. Stock removal during gashing varies up to a maximum of 1 inch wide by 3 inches long. After milling the twenty-three gashes, the cutter is changed to machine the concave contour on the vanes. The three-flute spiral slab-cutting end-mills are rotated at 920 R.P.M., and the table is fed at the rate of 9 1/4 inches per minute. Approximately thirty minutes is required to index the forging forty-six times and complete both cuts.

After burring and washing, the partially machined inducer is given an ultrasonic inspection to reveal any possible defects, such as holes or cavities, in the forging. This inspection consists

Fig. 3. Stock between fingers on inducer forgings is cut away in this gashing operation, and then concave contour of vanes is semi-finish-formed on the same machine

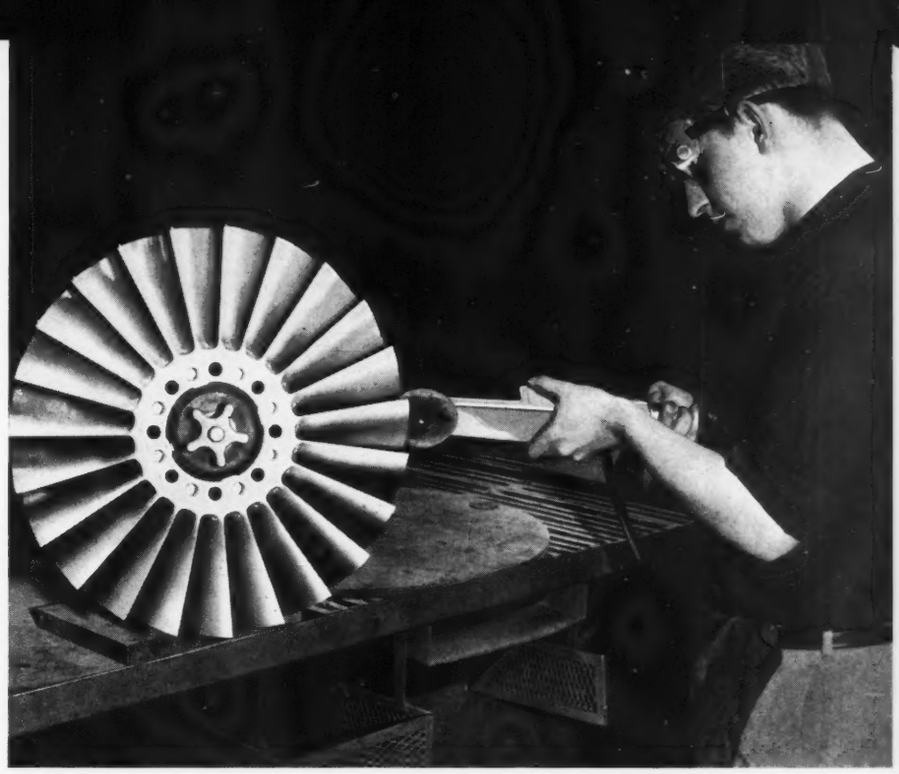


Fig. 4. Burrs are removed and surfaces of the milled inducer vanes are blended in this hand grinding operation. The surface finish required is 32 micro-inches r.m.s.

of directing ultrasonic impulses (inaudible high-frequency sound waves) onto the surfaces of the inducer and measuring the time required for these impulses to penetrate the forging and be reflected from it. The relative time taken for the impulses to be reflected indicates whether or not there are defects. The inducers are then solution heat-treated and artificially aged to produce an ultimate tensile strength of 58,000 pounds per square inch and a Brinell hardness of 120.

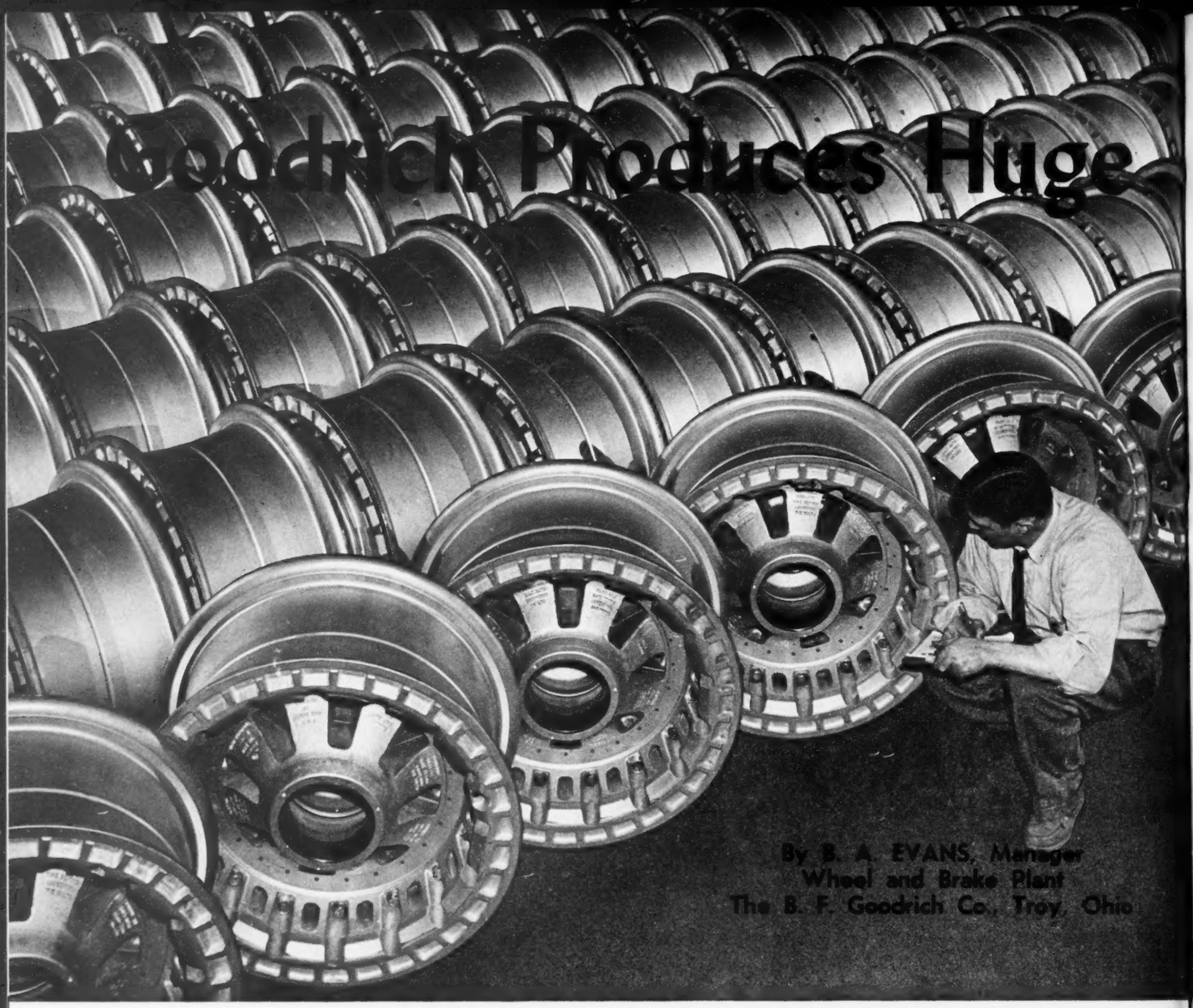
Both concave and convex contours of the inducer vanes are finish-machined on three more of the specially tooled milling machines. On each of these machines, one of which is seen in the heading illustration, the forging is indexed forty-six times, a longer smaller-diameter cutter being substituted after twenty-three indexings. Tips of the blades are machined to a minimum thickness of 0.090 inch.

The surfaces of the inducer vanes are finished by hand grinding, as seen in Fig. 4. The work is mounted on a universal swiveling bench fixture, and a specially designed pneumatic tool having a long, thin extension that fits between the vanes is used to remove the burrs and blend the milled surfaces. Aluminum-oxide abrasive pads (80 grit and 4 inches in diameter) are cemented to a rubber disc at the end of the tool. The pads are rotated at 2600 R.P.M. Care must be taken in this operation to maintain the vane thicknesses within $\pm$ 0.0025 inch, and obtain a surface finish of 32 micro-inches r.m.s.

After a dynamic balancing operation, the inducers are given a spin test, in which they are rotated at 15,000 R.P.M. for five minutes. This is accomplished by means of a 50-H.P. steam turbine, as shown in Fig. 5, with the inducer suspended in a pit below the floor. A partial vacuum is created in the pit during testing. It requires approximately ten minutes to bring the inducer up to speed, and about seven minutes to stop it. After spinning, the inducer has a permanent growth of 0.003 to 0.007 inch.

Fig. 5. Completely machined inducers are given a spin test in which they are rotated at 15,000 R.P.M. for five minutes by means of a steam turbine

Goodrich Produces Huge



By B. A. EVANS, Manager
Wheel and Brake Plant
The B. F. Goodrich Co., Troy, Ohio

MANUFACTURING facilities of the B. F. Goodrich plant at Troy, Ohio, are devoted to the production of many different types of wheels and brakes for use on airplanes from the smallest to the largest sizes. These wheels must combine maximum strength with the lightest possible weight. For example, each of the four wheels on the U. S. Air Force B-47—the world's fastest stratosphere jet bomber—must have a static load rating of 60,000 pounds, and must withstand the severe shock imposed by landing more than 100 tons at speeds exceeding 100 miles per hour. Each wheel carries a 56- by 16-inch, extra high pressure tire.

Wheels for this bomber are made in halves, which are bolted together at assembly, each half being a magnesium-alloy sand casting, approximately 33 inches in diameter by 10 inches wide and weighing 110 pounds. The casting alloy—Dow H or American Magnesium 265—contains 6 per cent aluminum, 3 per cent zinc, and the balance magnesium. As cast, the wheels have a tensile strength of 24,000 pounds per square inch, a yield strength of 10,000 pounds per square inch, and an elongation of 2 per cent in 2 inches. After a solution heat-treatment at a temperature of 775 degrees F. for from sixteen to twenty-four hours, the minimum tensile strength is increased to 34,000 pounds per square inch. The yield strength remains unchanged, but the elongation is increased to 7 per cent.

Practically all machining on the aircraft wheels is done on Bullard 36-inch vertical turret lathes of the type seen in Fig. 1. On the first machine, Fig. 2, the casting is bored, faced, and turned. The work is located from a previously turned registry diameter in a fixture that is clamped to the rotary table of the machine. Various surfaces of the wheel machined in this operation include the seats for the brake drum, anti-friction bearing, and tire bead; and the rim profile. The latter surface is tapered at an angle of 5 degrees. A tolerance of $\pm$ 0.001 inch must be maintained on the bearing seat bore.

Carbide-tipped, single-point tools are used in this machine. Average stock removal is 3/16

Magnesium Wheels

inch, or 3/8 inch on the diameter. The work is rotated at 200 R.P.M., giving surface speeds up to 1730 feet per minute, and the tools are fed at various rates ranging from 0.002 to 0.015 inch per revolution.

In the second operation, performed on another Bullard vertical turret lathe (Fig. 3), the remainder of the rim profile is taper-turned, the registry diameter is faced, and a pad on the rim flange is knurled. Stock removal, cutting speeds, and feeds are the same as in the previous operation. Machined surfaces on the castings are periodically inspected by means of a Profilometer to insure that the surface finish on the bearing seat and highly stressed areas such as the bead seat does not exceed 20 micro-inches r.m.s.

After drilling and milling an opening in the casting for the inner tube valve, and burring with portable electric tools, the wheel is given a final machine inspection. Castings are then given a dichromate (Dow No. 7) treatment to increase their corrosion resistance and provide a good paint base. No appreciable change in dimensions results from this treatment.

The dichromate treatment (Fig. 5) consists of immersing the parts in seven different baths: An alkaline cleaner; a cold water rinse; a 15 to 20 per cent hydrofluoric acid bath (at room temperature); another cold water rinse; a 45 minute dip in a 10 to 15 per cent solution of sodium dichromate maintained at a temperature of 200 degrees F.; a final cold water rinse; and then a

Fig. 1. Surface speeds up to 1730 feet per minute are employed in turning sand-cast magnesium wheels used on aircraft

Fig. 2. (Below) Set-up employed on a vertical turret lathe for boring, facing, and turning cast magnesium airplane wheel

Tie- and drum-bolt holes are drilled through the wheel castings in two operations performed on the Natco multiple-spindle drilling machine shown in Fig. 4. In the first operation, sixteen tie-bolt holes, 3/4 inch in diameter, are drilled simultaneously. Then, twenty-four drum-bolt holes, 5/16 inch in diameter, are drilled. While the previous turning, boring, and facing operations are performed dry, a mineral base cutting oil of low viscosity and high flash point is used in this drilling operation.

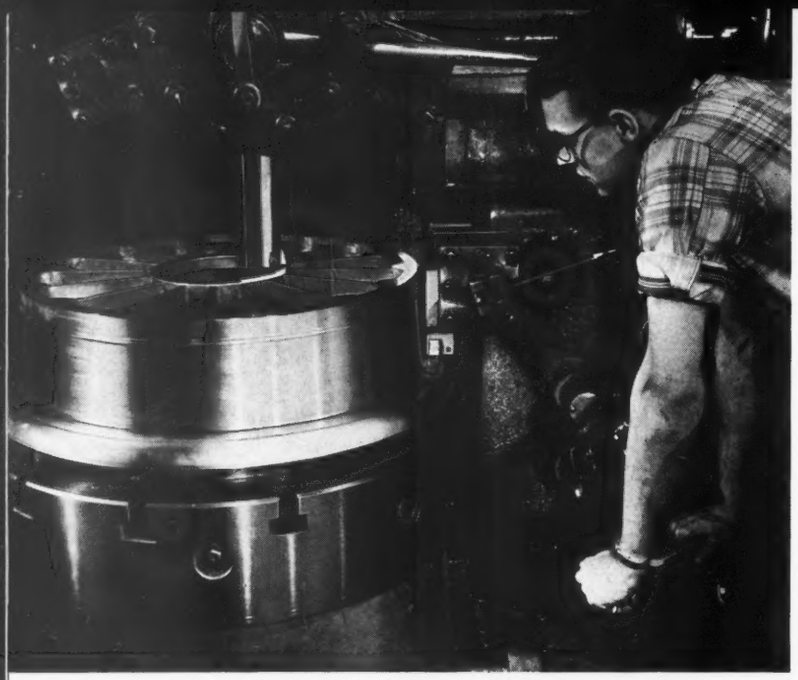


Fig. 3. A pad on the rim flange of the wheel casting is knurled and the registry diameter on the hub is faced in this set-up

Fig. 4. (Below) Sixteen tie-bolt holes and twenty-four drum-bolt holes are drilled in two operations on a multiple-spindle machine

Fig. 5. (Below) Cast magnesium airplane wheels are given a dichromate treatment to prevent corrosion and provide a paint base

hot water dip, which serves to dry the parts. A bronze color results from treating the magnesium alloy in this way.

The wheels are now painted with two coats of zinc chromate primer and one coat of aluminum lacquer. Outer races of the anti-friction bearings are then pressed into the wheel castings. The castings are heated and the bearing races cooled, giving a temperature differential of 300 degrees F., to permit assembly with the 0.010 inch interference required.

Next, each wheel half is statically balanced to within 5 inch-ounces prior to assembling with the brake drums, bearings, seals, etc. After a final inspection, the assembly is given another aluminum lacquer coat for further protection.

Five Hundred Dollars in Prizes for Articles on Ingenious Mechanisms

MACHINERY offers $500 in cash prizes for the eight best articles on ingenious mechanisms to be submitted to the Editor before November 1 of this year. Each article should be confined to a description of one mechanism or one mechanical movement that has proved its practicability in actual use and has not previously been described in the technical press. The money will be distributed as follows:

First prize	$200
Second prize	$100
Two additional prizes	$50 each
Four additional prizes	$25 each

In addition to these cash prizes, MACHINERY'S high-level space rates will be paid both for prize-winning articles and for all other articles accepted for publication that may not receive a prize.

Each contestant may send as many articles as he wishes. All will be entered in the competition and all may be accepted for publication; but no contestant will be awarded more than one prize.

Articles entered in this competition should be addressed to the Editor of MACHINERY, 148 Lafayette St., New York 13, N. Y., and must be mailed on or before November 1.

This competition applies to any kind of mechanism making use of a practical and ingenious mechanical motion or principle. The competition is open to all, whether subscribers to MACHINERY or not. The procedure is simple.

1. Send a drawing of the mechanism (or photograph if preferred—or both) that clearly shows all important parts of the particular movement to be described.

2. Describe as clearly as possible both the *purpose* of the mechanism and its *action—how* it does *what* it does.

3. Mark the important parts on the drawing, such as levers, cams, etc., with letters, *A*, *B*, etc., and use corresponding letters to identify those parts in the description; thus, "Lever *A* is operated by cam *B*." This will help to make the description readily understood.

4. Confine each article to a single mechanism or movement; do not describe an entire machine or refer to parts that do not affect the movement being described.

Clear blueprints or pencil drawings with distinct lines are satisfactory for illustration. They should be made on separate sheets of paper. Send only drawings that are to scale, with the various parts shown in correct relationship and proportion. Rough free-hand sketches cannot be used. The drawing must show the assembled mechanism, although a diagram or a drawing that is partly diagrammatic may be substituted to advantage, especially if it more clearly illustrates the arrangement of a mechanism that is particularly complicated.

It is more essential that important facts be clearly stated than that the manuscript be neatly written; but carefully prepared manuscripts usually indicate careful thought.

Avoid describing a mechanism that is familiar to most designers; descriptions of movements that are generally known cannot be accepted, even though they may be very ingenious. It is immaterial how long ago a mechanism or movement was designed, provided it has not previously been described.

Important Suggestions

Be sure to describe as clearly as possible both the purpose of the mechanism and its action — what it does and how it does it. Describe the purpose first, and the means of accomplishing it afterward.

Confine each article to a description of a single mechanism or mechanical movement. Do not describe the entire machine of which the mechanism or movement is a part. Clear descriptions of separate mechanisms rather than descriptions of entire machines are desired. Omit reference to parts of machine that do not affect the movement being described.

Do not describe mechanisms familiar to most designers. On the other hand it is immaterial how long ago a mechanism or movement was designed; but it must not have previously been described in any publication or textbook.

Gear Manufacturers Stage

(Left to Right) George H. McBride, newly elected president of the American Gear Manufacturers Association; S. L. Crawshaw, vice-president; and Louis B. Bond, treasurer

THE American Gear Manufacturers Association held its thirty-fifth annual meeting at the Homestead, Hot Springs, Va., June 4, 5, and 6. The meeting consisted of business and technical sessions and the discussion of pertinent problems in committee meetings. Two outstanding technical papers were presented—"New Plastic Materials for Non-Metallic Gears," by Fred R. Zumstein, of the Fellows Gear Shaper Co.; and "Powder Metallurgy—A New Process for Manufacturing Gears," by D. W. Lynch, T. J. Snodgrass, and T. T. Woodson, all of the General Electric Co.

Mr. Zumstein mentioned in his paper that a majority of the manufacturers of thermoplastic gears appear to favor the use of polyamide materials, which are more commonly called nylon. Nylon, according to Mr. Zumstein, possesses the highest heat resistance of the lower-priced thermoplastic materials, and for that reason, gears made of this material predominate in such applications as food mixers, cameras, projectors, business machines, lawn sprinklers, hydraulic pressure gages, automotive speedometers, electric windshield wipers, washing machines, and home temperature indicators. The self-lubricating characteristics of nylon, which are an advantage in plain bearings of textile equipment also provide a means of reducing friction between mating gear tooth surfaces.

The Massachusetts Institute of Technology has conducted a series of tests on non-metallic gears, and has worked out a velocity factor taking into account the low specific gravity of such materials as nylon and laminated phenolic gears. The specific gravity of these materials is less than one-seventh that of steel, with the result that low centrifugal stresses are obtained with plastic gears.

Experimental plastic gears have been made with copper shims to facilitate the conduction of heat from gear tooth areas and prevent undue wear and deformation from generated heat.

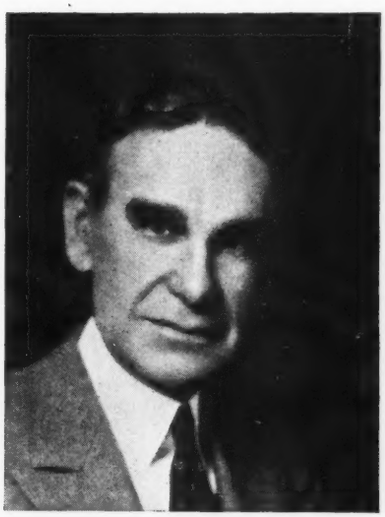
Mr. Zumstein discussed a considerable number of plastic gear applications, and pointed out that substantial cost savings can be made by the injection molding of a complete cluster of gears or an assembly of separate parts. He also pointed out that, in spite of a plastic material volumetric cost of approximately 10 per cent more than that of steel, plastic components in one instance were produced at one-tenth the cost of the original steel gears.

One concern recommends that, in cases where a nylon gear is to run with a corrosion-resistant part, the latter should be made of stainless steel rather than of a non-ferrous material, such as brass. The reason for this is that brass apparently has some affinity for nylon, even though highly polished, and tends to cause greater wear than stainless steel. The greatest cost-saving factor, of course, results from the production of a complete gear in one molding operation.

The paper on powder metallurgy dealt with the experience of the General Electric Co. in making gears from powdered metal, and stressed the increasing use of powdered-metal components for the moving parts of mechanisms com-

Thirty-Fifth Annual Meeting

pared with bearings and similar applications for which powdered metal has been largely used in the past. Typical gears made from powdered metal were discussed in detail. In one instance, it was pointed out that, in molding teeth in the hub of a dual gear, optimum strength was obtained by blending the flanks and root of the teeth with the hub in order to insure minimum stress concentration. It was mentioned that no other method of making accurate metal gears can allow such construction.



Edward W. Miller, recipient of Connell Award at Gear Manufacturers' meeting

Gears can be made with molded helical teeth, and, of course, splines, keyways, and various types of bores can be molded when a concentricity of about 0.005 inch is acceptable. Holes are usually bored or ground with respect to the pitch line in a pin chuck, for maximum concentricity after sintering. The outstanding advantage derived from powdered-metal gears is the saving of labor and time required for tooth formation. In most instances, a gear is produced in one press operation at a rate of from two to fifteen seconds per gear. Sintering, steam or oil treatments, and metal impregnation are usually accomplished by the use of conveyor type equipment.

The sessions on Monday and Tuesday, and the annual dinner on Tuesday evening, were presided over by Leroy Brooks, Jr., president of the Association, and president of the Tool Steel Gear & Pinion Co., Cincinnati, Ohio. The chairman of the Wednesday morning session was George H. McBride, manager of the Gearing Division, Westinghouse Electric Corporation, who is the newly elected A.G.M.A. president. Mr. McBride joined the Westinghouse Nuttall Works in 1922 after completing a course in business administration at the University of Pittsburgh. He has been active in the Association for several years, serving as a member of various committees, and for the last year as vice-president.

S. L. Crawshaw, assistant to the president, Western Gear Works, Seattle, Wash., was elected vice-president of the Association. Mr. Crawshaw has spent his entire business career in the gearing industry. Prior to his present connection, he was chief engineer of the Nuttall Works, Westinghouse Electric Corporation. He is at present a member of the executive committee of A.G.M.A. Louis B. Bond, vice-president and general manager of the Christiana Machine Co., subsidiary of the Charles Bond Co., Philadelphia, Pa., was re-elected treasurer.

The following were elected to the executive committee: Marvin R. Anderson, executive vice-president, Michigan Tool Co., Detroit, Mich.; Gunnar E. Gunderson, vice-president of the Brad-Foote Gear Works, Inc., Cicero, Ill.; R. B. Holmes, general manager, Philadelphia Works of the Link-Belt Co.; and Charles R. Kessler, president, Beaver Gear Works, Inc., Rockford, Ill.

An outstanding event of the annual dinner was the presentation of the Connell Award to Edward Whitney Miller, president of the Fellows Gear Shaper Co., in recognition of the leadership he has displayed through the last thirty-five years in the development of sound principles in gear engineering. Mr. Miller has been active in the gearing industry throughout his entire business career, and is the author of numerous articles on gear theory and the art of gear production. He has served the Association in many capacities, including that of president, which office he held for two years.

In his introductory address at the dinner, President Brooks referred to the recent resignation of Newbold C. Goin, executive secretary, as a "great loss of a worthy secretary."

Joseph T. Vinbury Wins The Industrial Press Award

THE Industrial Press Award of $1000, which was established by the publishers of MACHINERY to be given to the industrial advertising man who has made, during the last year, the best documented presentation to his management to prove the need for a specific advertising program and has shown how that program has filled the need, was won by Joseph T. Vinbury, advertising manager of the New Britain Machine Co., New Britain, Conn. The Award was presented to Mr. Vinbury on June 26 at the annual convention of the National Industrial Advertisers Association, which was held at the Hotel Waldorf-Astoria in New York City.

Joseph T. Vinbury, advertising manager of the New Britain Machine Co., winner of The Industrial Press Award

Entries in the contest were carefully considered by a panel of judges set up by the Awards Administrative Committee of the N.I.A.A. The panel consisted of M. R. Greiser, president, Carthage Mills, Inc., Cincinnati, Ohio; George H. Lynn, general sales manager, Baldwin-Lima-Hamilton Corporation, Hamilton, Ohio; John McConnell, vice-president, American Air Filter Co., Louisville, Ky.; C. S. Stackpole, vice-president and general manager, Air-Temp Division, Chrysler Corporation, Dayton, Ohio; and T. Spencer Shore, president, Eagle-Picher Co., Cincinnati, Ohio.

Mr. Vinbury graduated from Boston College in 1940, and after graduation worked for the Hamilton Standard Division of the United Aircraft Corporation, where he gained practical experience in the operation of machine tools. From 1942 to 1943, he was with the Army Air Corps, after which he became a teacher of English and physical education. In 1946, he became advertising manager of the New Britain Machine Co. Mr. Vinbury at present is serving as chairman of the New England Machine Tool Builders' Advertising Council.

In addition to the first prize awarded Mr. Vinbury, honorable mention was given to entries of the following: Alfred H. Roth, of Towmotor Corporation; John I. Carr, of Owens-Illinois Glass Co.; and Frank Little, of the Precision Scientific Co.

In presenting the Award to Mr. Vinbury, Robert B. Luchars, president of The Industrial Press, pointed out that advertising managers are at times painfully conscious of the fact that sound advertising is not always encouraged by top management officials and is even, on occasion, actively opposed. As a result, many able advertising men have sometimes found themselves seriously hampered in their effort to develop an effective program of industrial advertising for the organizations with whom they are connected.

Mr. Luchars went on to say that the indifference or active hostility toward sound industrial advertising springs from a variety of causes, the commonest one being the failure on the part of some top company executives to see the need for advertising or to recognize its practical value. Most top-ranking industrial executives are realistic and ready to face facts. However, no executive can be enthusiastic about something for which he sees no practical need.

He said that the job, then, is to establish the need for advertising, so that it will be fully recognized and understood. That means assembling and presenting pertinent and thoroughly authenticated facts which give a clear picture of what must be done to keep pace with the fast moving parade of new market requirements, personnel changes, product developments, and competitors' activities. The supposition that the sales promotion job can be done completely by the personal selling staff is a fallacy that arises chiefly from lack of first-hand contact with field conditions, and the consequent failure to understand the serious gaps and weak spots that exist in the

front line of even the best personal selling organizations.

Once top management has been shown that there are such gaps and weak spots, the vulnerability of sole dependence on the personal sales force becomes apparent, and the need to plug the gaps and reinforce the weak spots is immediately evident. There can no longer be any reasonable room for doubt that something needs to be added, and an advertising program built to conform to the needs pattern will commend itself strongly and should be relatively easy to sell.

Mr. Luchars then explained that the objective of The Industrial Press Award is to encourage advertising men to develop a convincing presentation to their top company management, showing why and where advertising is needed to supplement and reinforce activities of the selling staff, or otherwise to perform essential development work, and outlining a program of advertising that fits the pattern of that need. The idea was that such a competition would stimulate effective action along these lines, encouraging and assisting others who might be in the need of help not only by demonstrating that this sort of job could be done, but also by showing how it has been done.

Thanks were expressed to the judges for the time and energy expended, and also to R. W. Darrow of the Glenn L. Martin Co., chairman of the Awards Committee, to Blaine G. Wiley, executive secretary of N.I.A.A., and to W. R. Northlich of the Farson, Huff & Northlich Agency, who organized the panel of judges and carried the job through to a successful conclusion.

New ASTM Officers Announced

The American Society for Testing Materials has announced the election of the following new officers for the year 1951-1952: President, Truman S. Fuller, engineer in charge of Works Laboratory, General Electric Co., Schenectady, N. Y.; vice-president, Leslie C. Beard, Jr., assistant director of Socony-Vacuum Laboratories, New York City.

Mr. Fuller has participated in the work of the Society for many years. He served as a member of the board of directors for several terms, and was elected vice-president last year. He has been an active member of a large number of the society's technical committees in many materials fields. Author of many papers, particularly on metals and alloys, Mr. Fuller is also active in the work of other technical societies and organizations. Mr. Beard is also a long-time member of the Society. He has been particularly active in the committee on petroleum products and lubricants, and has served as chairman of several of the sub-groups. At the present time, he is first vice-chairman of the main committee. He serves on the New York District Council and is a member of the ASTM Administrative Committee on Research.

* * *

Average hourly earnings of all wage earners in the iron and steel industry in 1950, prior to the December increase, were $1.725, or almost exactly double the 1940 average.

Panel of judges established by the National Industrial Advertisers Association to determine the winner of The Industrial Press Award. (Left to Right) Front row: John McConnell, C. S. Stackpole; Back row: M. R. Greiser, T. Spencer Shore, and George H. Lynn

Multiple Operations Performed on Broaching Machine

While broaching machines are often thought of as single-purpose machines, they are frequently used to perform multiple operations on different parts or even on the same part. An example of the latter application is illustrated in Fig. 1. The operation, which is performed on a Colonial 15-ton 24-inch stroke press, consists of broaching the holes for nine valve and push-rod guides in tractor-engine cylinder heads, assembling the nine guides, and broaching the guides to size. The eighteen broaching operations and the nine assembling operations are performed in two cycles (consisting of four strokes) without removing the cylinder head from the machine.

At the beginning of the cycle, the operator slides the cylinder head into place in the machine. Retracting type locating pins, interlocked with the operation of the machine, locate the head while it is being locked in position with hydraulically actuated, manually controlled clamps. Nine broaches—six of one size for the valve guide holes, and three of another for the push-rod guide holes—now broach the holes on the down stroke of the press. At the end of the stroke, the broaches are automatically released and drop into a partitioned receptacle in the base of the machine. Meanwhile, the head of the machine returns automatically to its uppermost position.

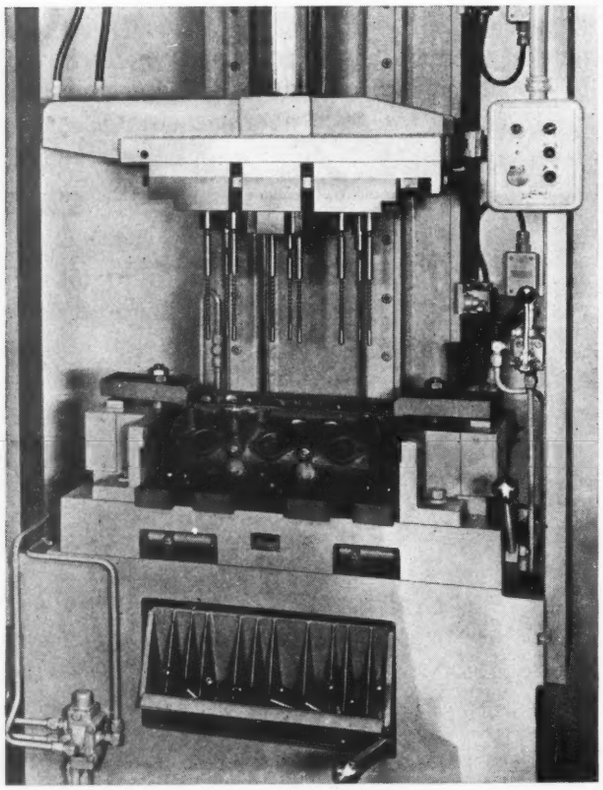


Fig. 1. Eighteen broaching and nine assembling operations are performed on a cylinder head in four strokes of this press

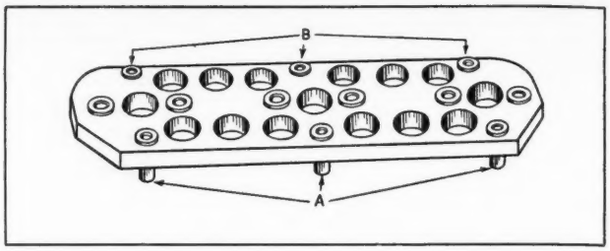


Fig. 2. Aluminum pallet for loading broaching tools. Holders (A) are used for supporting right-hand cylinder heads, and holders (B) for left-hand heads

While this is taking place, the broaches for the guides themselves are being placed in an aluminum pallet, and the corresponding valve or push-rod guides are slipped over the top ends of the broaches. The light-weight pallet, Fig. 2, is lifted into position under the head, engaging the upper broach ends in the pullers on the head. A lever locks the broaches in the pullers, the pallet is removed, and the head moves down. As it does, the guides are pushed into the previously broached holes. A stop for the head insures that the guides are pushed in to exactly the right depth. On the return upward stroke of the head, the broaches are pulled through the guides, thus finishing their bores to size.

The pallet is now lifted into place again and the broaches are released, dropping into their respective holes in the pallet. A lever at the base of the machine is used to bring the receptacle containing the guide-hole broaches out of the base. These broaches are reinserted in the head manually, ready for performing the operations on the next cylinder head.

With this set-up, the valve guide broaches actually serve as "inspection" tools for the fit of the guides in the broached cylinder-head holes. If the fit is too loose, the broaches pull the guides back out of the holes on the return stroke of the head. This is due to the fact that it takes less effort to broach the bore of the guides than it does to push the guides into place if the fit is correct.

Performing all operations in the same set-up also assures that the spacing between the various valve and push-rod guides is closely maintained. Accuracy of the hole and guide bores is held to $\pm$ 0.0005 inch. The set-up here illustrated is so designed that two different sizes of cylinder heads can be handled on the same machine. Different broach sizes are used, of course, for the two heads.

TOOL ENGINEERING *Ideas*

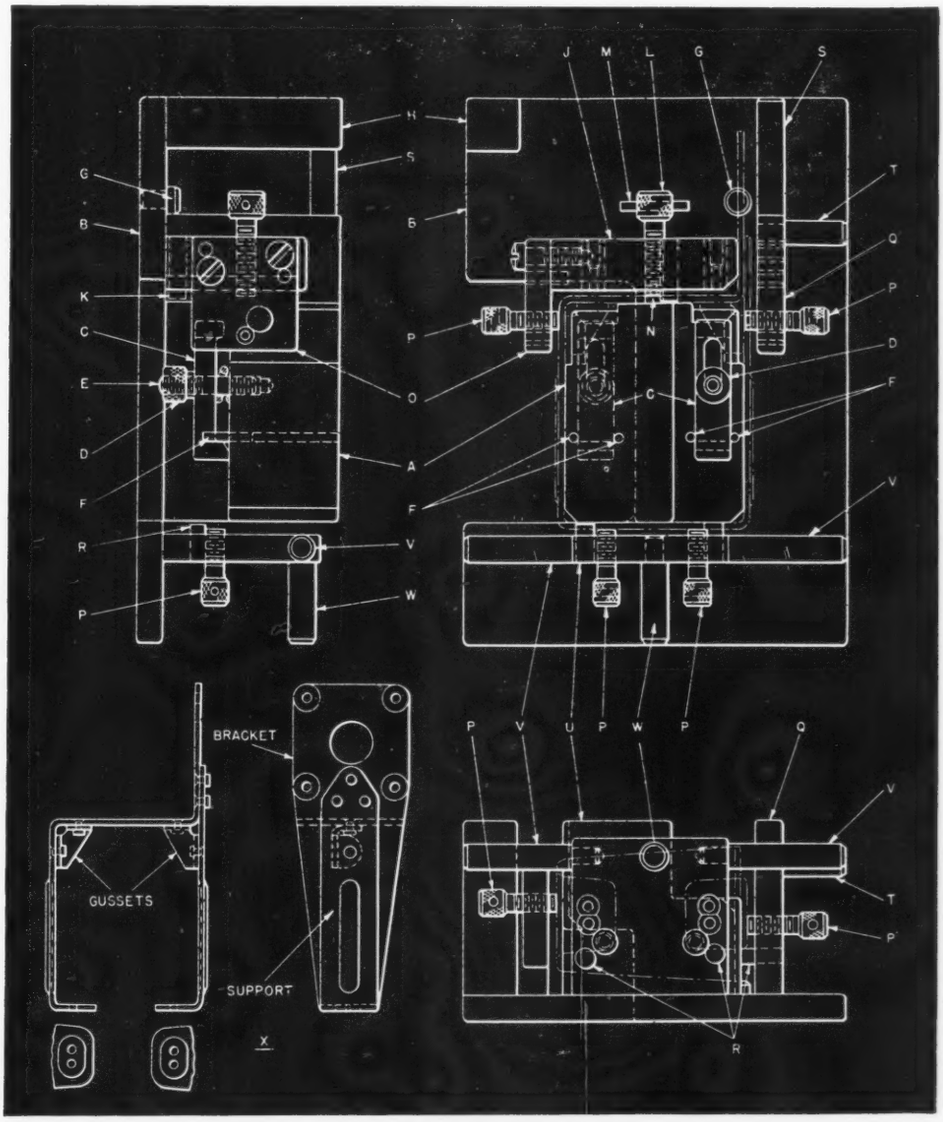
Tools and Fixtures of Unusual Design and Time- and Labor-Saving Methods that Have been Found Useful by Men Engaged in Tool Design and Shop Work

Jig Designed to Drill Sub-Assemblies

By ROBERT W. NEWTON, Tool Engineer
International Business Machines Corporation
Poughkeepsie, N. Y.

The clamping together of several sub-assemblies into their final assembled position and then drilling holes in them is a highly successful technique used in the aircraft manufacturing industry, but one that is not too widely employed in other fields. After the drilling operation has been completed, the parts can be separated and put in stock, and when they are assembled, no trouble is experienced in fitting them together.

This method was employed in drilling thousands of frames for airplane automatic control



Jig employed for drilling the bracket, support, and two gussets of a control-box frame while the parts are clamped in their final assembled positions

boxes such as the one seen at *X* in the accompanying illustration. The aluminum-alloy frame consists of a bracket, a support, and two gussets, all riveted together. It was required to drill all the rivet holes necessary in each part for fastening the parts together, as well as for fastening the control box to the frame. Bolt holes provided in the bracket for fastening the completed assembly to the airplane were drilled in a separate operation.

Individual jigs for drilling each part would have been expensive to build, because of the odd shapes of the parts. Also, if the parts were drilled separately, it was feared that they might not fit together properly or that the assembly would have a poor appearance. It was finally decided to drill all of the rivet holes with the pieces clamped together in their assembled positions. The jig designed for this purpose is shown in the illustration.

Master block *A*, which is screwed and doweled to baseplate *B* of the jig, is machined to provide a slip fit for the inside dimensions of the frame assembly. Steps are machined in the master block, from the top of the block on one side and from the bottom on the opposite side, to position the two gussets. The master block is also chamfered to provide clearance for the rounded corners of the bracket, support, and gussets.

The gussets are held in place against the master block by two sliding clamp assemblies. Each assembly consists of a slotted clamp *C* that is operated by a knurled nut *D*. The nuts are mounted on studs *E*, which are screwed into the master block. Two pins *F*, driven into the master block, keep each clamp aligned and allow movement of the clamps in one direction only. Baseplate *B* is slotted to provide a means for loading one of the gussets and for operating one of the sliding clamp assemblies.

One edge of the frame bracket rests on a locating button *G*, which is driven into the baseplate. The bottom surface of the baseplate serves as the legs necessary for supporting the jig when drilling rivet holes in the sides and ends of the frame assembly. A block *H*, which is screwed and doweled to one corner of the baseplate, provides additional resting surfaces.

Bushing block *J*, also screwed and doweled to the baseplate, is machined to provide a slip fit for the inner surface at the upper end of the bracket. Two bushings are driven into this block for guiding the drills used to produce the rivet holes through the bracket and one leg of each gusset. A locating pin *K*, for positioning the frame bracket vertically, is also driven into the bushing block. The frame bracket is clamped by means of a knurled-head screw *L* that is threaded through the bushing block. A pin *M*, short enough to clear the drill bushings, is driven through the head of this screw to provide additional clamping pressure. To prevent the soft aluminum work from being marked by this and other clamping screws, fiber plugs *N* are driven into the ends of the screws.

A second bushing block *O* is secured to one end of bushing block *J*. The single bushing provided in block *O* guides the drill used to produce a rivet hole passing through the side of the bracket and the other leg of one of the gussets. A knurled-head screw *P* provides additional clamping pressure against the bracket and gusset. Since a pin driven through this screw-head would extend over the bushing and interfere with the drilling operation, a hole is drilled through the head instead. If additional force is required to tighten or back off this clamping screw, a piece of drill rod may be inserted in the hole.

On the opposite side of the jig, a third bushing block *Q* is screwed and doweled to the baseplate. Four bushings are pressed into this block for drilling additional holes in the support, bracket, and other gusset. A locating pin *R*, for positioning the support vertically, is also provided in this block. Another knurled-head screw *P* is threaded through the block to clamp the bracket, support, and one of the gussets. Two pins *S* and *T*, one driven into the end and the other into the side of the block, serve as supporting legs for the jig.

A fourth bushing block *U* is secured to the front end of the baseplate. Four bushings are pressed into this block for drilling the mounting holes in the bottom of the bracket and support. Flats must be provided on these bushings because of the close center distances of the holes. Two more locating pins *R* are provided on the block, one for positioning the bracket and the other for the support. Also, two additional screws *P* are threaded through this block, one for clamping the end of the bracket and the other for clamping the end of the spport. Two pins *V*, one driven into each end of this bushing block, and pin *W*, driven into the outer face of the block, serve as additional supporting legs for the jig.

Fixture for Milling Four Surfaces on a Long Slender Part

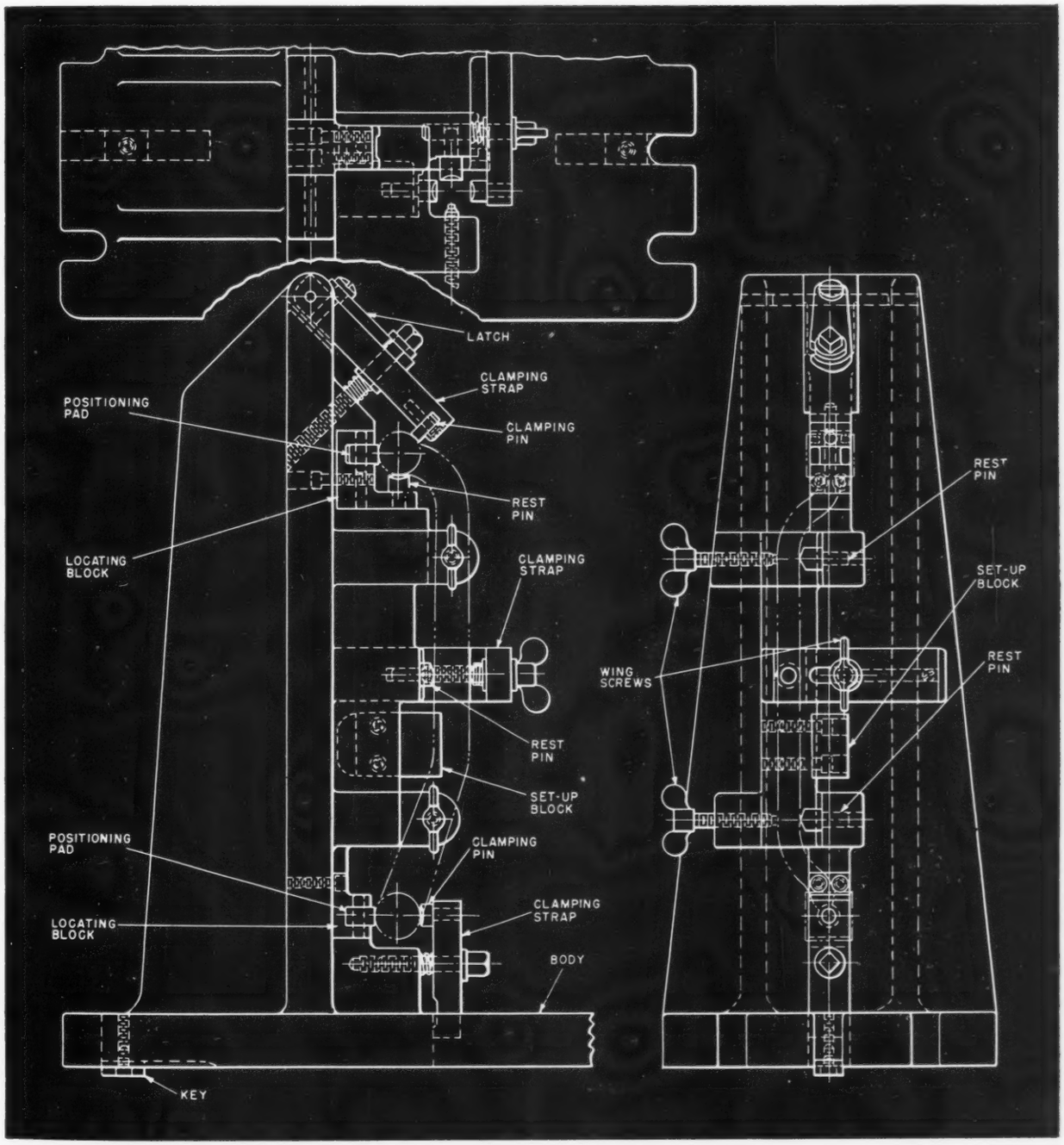
By ROBERT MAWSON, Shawomet, R. I.

In milling the two faces of both bosses on the part indicated by dot-and-dash lines in the illustration, considerable stress is set up because of

the distance between the bosses on the long slender part. The rugged fixture shown was designed to resist such stresses, and, at the same time, accurately locate the part to permit interchangeable manufacture. The part is a cast-iron narrowing arm link for knitting machines made by the Wildman Mfg. Co., Norristown, Pa., and this operation is performed on a four-spindle duplex milling machine.

Keys are secured to the under side of the cast-iron body of the fixture to facilitate locating it on the slotted milling machine table. Hardened steel positioning pads are pinned to locating blocks mounted near the top and bottom of the fixture body. In horizontal alignment with the lower pad is a hardened steel clamping pin that is mounted in the upper end of a clamping strap. The spring-loaded strap is pivoted toward the work by tightening a square-headed set-screw, which passes through the strap and is threaded into the fixture body. A hardened steel rest-pin is held in the lower face of the upper locating block.

Three more rest-pins are driven into holes reamed in bosses cast on the fixture body. The work is forced into contact with the centrally



Rugged fixture employed for accurately locating and rigidly clamping the long slender part shown by dot-and-dash lines while milling the faces of two bosses

located pin by means of another spring-loaded clamping strap, which is actuated by a wing-screw threaded into the body. The work is held directly in contact with the other two rest-pins by two more wing-screws. A hardened tool-steel set-up block, secured to a finished surface on the body casting directly below the center rest-pin, is used to locate the milling cutters with relation to the fixture when it is mounted on the milling machine table.

A third spring-loaded clamping strap is free to pivot about a pin mounted in the top of the fixture body. The clamping pin at the lower end of this strap is forced against the work by tightening a square-headed screw that is threaded into the body. A latch, which can be swung under the head of the screw, is attached to the upper face of the strap.

With the latch moved out from under the head of the screw, the top clamping strap can be swung upward to the open or loading position. Then, by loosening the three wing-screws and the screw on the bottom strap, a part can be loaded into the fixture.

Grinding Wheel Dresser with Variable Height Adjustment

By W. M. HALLIDAY, Birkdale, Southport, England

In truing the wheel on tool or surface grinding machines with a dresser having a fixed height, it is necessary to alter the settings of either the wheel-head or work-table, or both, in order to adjust the distance between the wheel and table. Such changes are particularly undesirable when truing is necessary between rough and finishing operations, as they may result in dimensional errors on the finished work-piece.

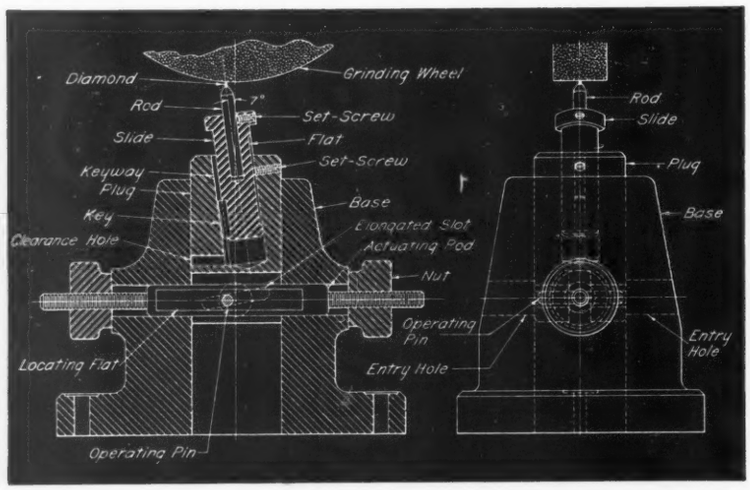
The diamond dressing fixture illustrated is designed especially to overcome this difficulty. With this fixture, the diamond can be adjusted to any height above the grinder table within a considerable range. Provision is also made for a particularly fine rate of diamond feed.

The cast base of the dressing fixture is bored to accommodate a sliding vertical plug. A flattened cylindrical actuating rod, which is supported horizontally in holes machined through the walls of the base, fits into a narrow slot in the lower end of the sliding plug. The distance between flats on the rod is made about 0.015 inch smaller than the slot width to allow a free sliding movement. Knurled nuts that engage threads on both ends of the actuating rod normally bear against bosses on the base.

An operating pin, made about 1/8 inch shorter than the diameter of the vertical plug, is pressed into a hole cross-drilled through the flatted portion of the actuating rod. The projecting ends of this pin fit into two elongated, inclined slots in the side wall on the slotted end of the plug. With this arrangement, the vertical plug is raised and lowered when the actuating rod is moved to the left and right, respectively. The operating pin can be inserted in the rod at assembly, or removed when replacement is necessary, through entry holes machined in the cast base.

A hole, bored at an angle of 7 degrees from the vertical in the upper end of the plug, contains the cylindrical slide in which the diamond dressing rod is mounted. The slide is keyed to the plug to prevent rotation. In manufacturing the fixture, a radial hole is drilled from the periphery to the bore of the plug to provide clearance for the keyway cutting tool.

The slide can be locked in the vertical position desired by means of a headless set-screw, which bears against a flat machined on the slide. A set-screw is also screwed into the slide for adjusting the diamond-dressing rod vertically. The slide and rod are mounted in an angular position so that the rod can be rotated occasionally to pre-



Grinding wheel dressing fixture in which vertical adjustment of the diamond is obtained by moving the rod in which the diamond is set or the slide in which the rod is mounted. Very fine vertical adjustments can also be obtained by moving the actuating rod

sent a different cutting facet to the abrasive wheel. If the rod were mounted straight, cutting would always occur on the extreme tip of the diamond.

In operation, either the slide or the rod, or both, are raised to bring the diamond within about 1/64 inch of the grinding wheel surface to be trued. Then, with the slide and rod locked, the diamond is raised the slight additional amount needed to bring it into the dressing position by moving the actuating rod to the left. Initially, the vertical plug should be set in its lowermost position by moving the actuating rod to the extreme right.

The actuating rod is moved, of course, by loosening the nut on one end and tightening the one on the opposite end. By providing fine-pitch threads on the ends of the actuating rod and a low angle of inclination on the elongated slots, extremely fine, vertical feeding adjustments can be obtained with a slight movement of the nuts. If desired, the peripheries of the nuts can be graduated to give visual indication of the amount the diamond is raised.

* * *

Norton Produces New Grinding Wheel Film

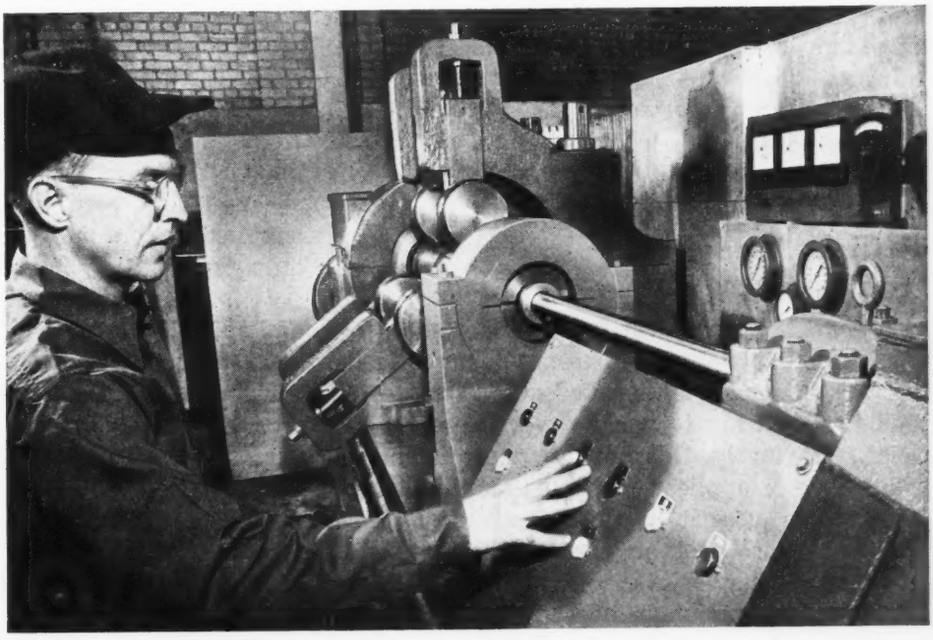
A thirty-minute, 16-millimeter color motion picture on abrasives and grinding wheel manufacture, known as "Grits that Grind," has been made by the Norton Co. The film shows, step by step, manufacturing processes—from the mining of bauxite to the finished product. It is available without charge on loan by writing to "Grits that Grind," Norton Co., Worcester 6, Mass.

High-Speed Trepanning of Alloy Steel Bar Stock

A rough-turning lathe modified for performing high-speed trepanning operations on a production basis is shown in the accompanying illustration. It is claimed that this machine will greatly expedite the production of such defense items as gun barrels and housings, as well as peacetime work. The lathe was built by the Heppenstall Co., Pittsburgh, Pa.

Modified features of the lathe include a variable-voltage main drive, a gearless headstock, and infinitely variable hydraulic feed. As seen in the illustration, a push-button control panel is provided. Instruments indicate the per cent of load on the main motor drive, rate of feed in inches per minute, surface feet per minute at the point of the cutting tool, revolutions per minute of the main spindle drive, coolant pressure, and temperature.

As an example of the high cutting speeds obtainable with this equipment, a penetration rate of 480 inches per hour was attained in creating an accurate, smooth finish bore, 2 5/8 inches in diameter, in a steel bar 8 inches diameter by 4 feet long. A solid core, 1 1/8 inches in diameter, was removed after trepanning. The bar was made for a modified A.I.S.I. 4140 steel (Heppenstall Grade 9-R-40), having a Brinell hardness of 302. The work was rotated at 850 R.P.M., and the tungsten-carbide trepanning tools were fed at a rate of 0.008 inch per revolution. Further machining or honing of the bore is generally unnecessary. It is stated that lathes of this type can be built for handling much larger stock than that referred to in the foregoing example.



Rough-turning lathe modified to permit high-speed trepanning of alloy-steel bar stock. The lathe has a variable-voltage main drive and infinitely variable hydraulic feed

Materials OF INDUSTRY

The Properties and New Applications of Materials Used in the Mechanical Industries

Alloys Containing Cerium Solve Hot-Working Problems

Research in the laboratories of the Carpenter Steel Co., Reading, Pa., has disclosed that the addition of cerium to ferrous and non-ferrous alloys imparts a greater degree of hot workability to these metals. This discovery is of importance in that it overcomes obstacles to the use of many strategic corrosion- and heat-resistant steels that have heretofore been difficult to work in the hot state. Such steels can now be produced in the bar, rod, sheet, and tube forms so important to the defense effort.

Applications for which the cerium-bearing alloys are suitable include heat-resistant baffles and shields, heat-resistant parts for jet and turbo-jet aircraft, and heat- and corrosion-resistant valves for internal combustion engines. Advantages claimed for these alloys include fewer rejections in hot-working due to cracks and tears, as well as better finish, requiring less machining.

The Carpenter corrosion- and heat-resistant grades included in the new cerium-bearing alloy range are stainless AISI Types 309, 310, 316, 317, and 330, as well as Carpenter stainless 20 and austenitic valve steels. 62

Cement Metal-to-Metal Bond of High Strength

A rubber cement that bonds metal to metal with great holding power has been developed by the B. F. Goodrich Co., Akron, Ohio. "Plastilock," as this material is called, was first used to bond brake lining to brake-shoes in motor vehicles. Obviously, this bonding material has a wide range of applications. One manufacturer, for example, uses it to make a stronger, more serviceable gasoline tank by cementing the metal sections together. Nuts, bolts, and gaskets formerly used are no longer needed. 63

Thin Electrical Steel Reduces Weight of Airborne Equipment

A thin electrical steel with unusual properties, known as "Tran-Cor T-O-S," has been developed by Armco Steel Corporation, Middletown, Ohio. It is intended for use in wound type transformers and reactors that operate at 400 cycles. This new steel can be employed at very high inductions—considerably higher than those for which nickel-iron alloys are suitable. It was developed primarily to permit the reduction in size and weight of airborne electrical equipment.

Properties of the new steel include a density of 7.65 grams per cubic centimeter, a volume resistivity of 282 ohms per mil foot, and a lamination factor of 95 per cent solid. It is available in strips 0.004 inch thick and in 12 3/8-inch wide rolls. The strip can be bent flat over a small radius and then straightened without cracking. It can also be slit or sheared. 64

Ductile Brasses with Greater Strength and Hardness

Ductile brasses having increased strength and hardness are being produced by the American Brass Co., Waterbury, Conn. These copper alloys, known as "Formbrite," come in the form of sheets, strips, wires, rods, and tubes, and can be supplied to conform to ASTM specifications for either quarter- or half-hard stock.

It is said that this metal is stronger, harder, and springier than ordinary drawing brass, and yet retains sufficient ductility for deep-drawing, forming, and cold upsetting. The fine-grained structure of these alloys provides so smooth a surface that ordinary buffing produces a lustrous finish. The properties of this material make it possible to use thinner sections in the cold fabrication of parts. It is easily machined, and can be used in the manufacture of such wire products as rivets and screws. 65

To obtain additional information about materials described here, use Inquiry Card on page 253.

THE SALES ENGINEER AND HIS PROBLEMS

By BERNARD LESTER
Lester and Silver
Sales Management Engineers
New York and Philadelphia

What About Handling Materials?

EVERY first-rate salesman of metal-working equipment is well informed on the characteristics of the materials his machine cuts or shapes. But is he well informed on the best methods of handling materials—of transporting work to and away from the machine?

The following might appear in the diary of a sales engineer of materials-handling equipment, for it is a true incident:

"Called on Victor Andrews, vice-president of Fortune Appliance Co. today. Just got started when Joe Burns, his superintendent, butted into the office. 'Hot news, boss,' Joe said, as he held up a small machined part. 'Got our new machine going! We can save five cents on every piece. On 2000 a month, we will save $1200 a year. That's factory cost—just figure this out on the selling price!'

"Andrews got up and shook Joe's hand. 'Best news I've heard since I got rid of my termites.' Then I asked Andrews what does it cost to handle this material, carry away the waste and all that? He simply didn't know. Said that it was just part of his shop overhead."

Of course we focus our attention on selling the machine equipment and what it will do with the various materials it can handle. But don't most of us neglect the movement of materials? Why should we, as machine tool sales engineers, bother with material-handling problems? There are some very good reasons.

First, the efficient handling of materials offers the greatest opportunity there is today for increasing the operating efficiency of most plants.

Second, the machine is usually just one member of a group that goes to make up a production process. The success of each machine depends on the movement of materials. After all, what interests management most is general operating efficiency.

Third, in being informed on the best way of handling materials, the equipment salesman can offer suggestions that will aid his customer to make the best use of the machine he sells.

Fourth, even when we limit our thinking to the individual machine we sell, we can always advantageously stress those selling points by showing how easily the machine "takes" the work passed to it, and "delivers" it when complete. We can particularly point out the way it gets rid of waste materials, ready for some means of recovery.

Fifth, the equipment salesman can benefit from a friendly relationship with salesmen of material-handling equipment.

Sixth—a reason we can't repeat too often—the best salesman is the salesman who sells those ideas that will help his prospect the most.

Anyone visiting the materials-handling exposition in Chicago the month before last could not fail to have been impressed with the wide variety of equipment developed for all forms of materials handling. He would also have been impressed with the intimate relation existing between machines that process the product and equipment that does nothing whatever to it except move it safely and quickly from place to place.

Purchasers of shop equipment have frequently pointed out that a salesman should broaden his vision beyond the equipment he sells—broaden his action, so that he is not just a man who builds up a case for swapping a machine for so many dollars; broaden it to the point where he becomes a part of his prospect's thinking of how to improve manufacturing operations.

Let's get better informed on the most efficient way to handle materials. Then we can add one more "plus" to the value of selling the prospect useful ideas.

LATEST DEVELOPMENTS IN *Shop*

Massive New Electronically Controlled Machine for Manufacture of Reinforced Aircraft Skins

A new defense tool, capable of producing lighter yet stronger jet aircraft skin structures, has been brought out by the Giddings & Lewis Machine Tool Co., Fond du Lac, Wis. This revolutionary machine, designated the "Hypro aircraft skin mill," has been developed to adapt jet aircraft to meet the demands of near-sonic speeds, and is believed to be the first machine tool built for the manufacture of self-reinforced aircraft skin.

Details of this complex tool were jointly designed by engineers of Giddings & Lewis, General Electric Co., and Lockheed Aircraft Corporation in accordance with basic Lockheed specifications. The machine will be used in Lockheed's "Hall of Giants" fabricating plant in Burbank, Calif., in the production of the new F-94 jet fighters.

Electronically controlled by G-E equipment, the machine will be capable of manufacturing self-reinforced aircraft skins from sheets of solid or rough-forged aluminum alloy. This method of manufacturing airplane surfaces and their strengthening elements as one unit is said to permit the use of thinner wings and smaller fuselages for high-speed jet flying. Use of this new type structure eliminates the necessity of welding or riveting the customary forest of struts, braces, and girders into place. The decreased structural weight of the plane obtained by the new production methods will allow the addition of more weapons for greater firepower, increased fuel capacity, and additional instrumentation.

The massive new machine tool is 18 feet high by 30 feet wide by 80 feet long, and weighs 200 tons. In operation, it automatically cuts, edges, and shapes a particular pattern in three dimensions in one surface of a metal sheet. A two-dimensional electronic tracer control causes the machining equipment to cut the pattern laterally and longitudinally according to a

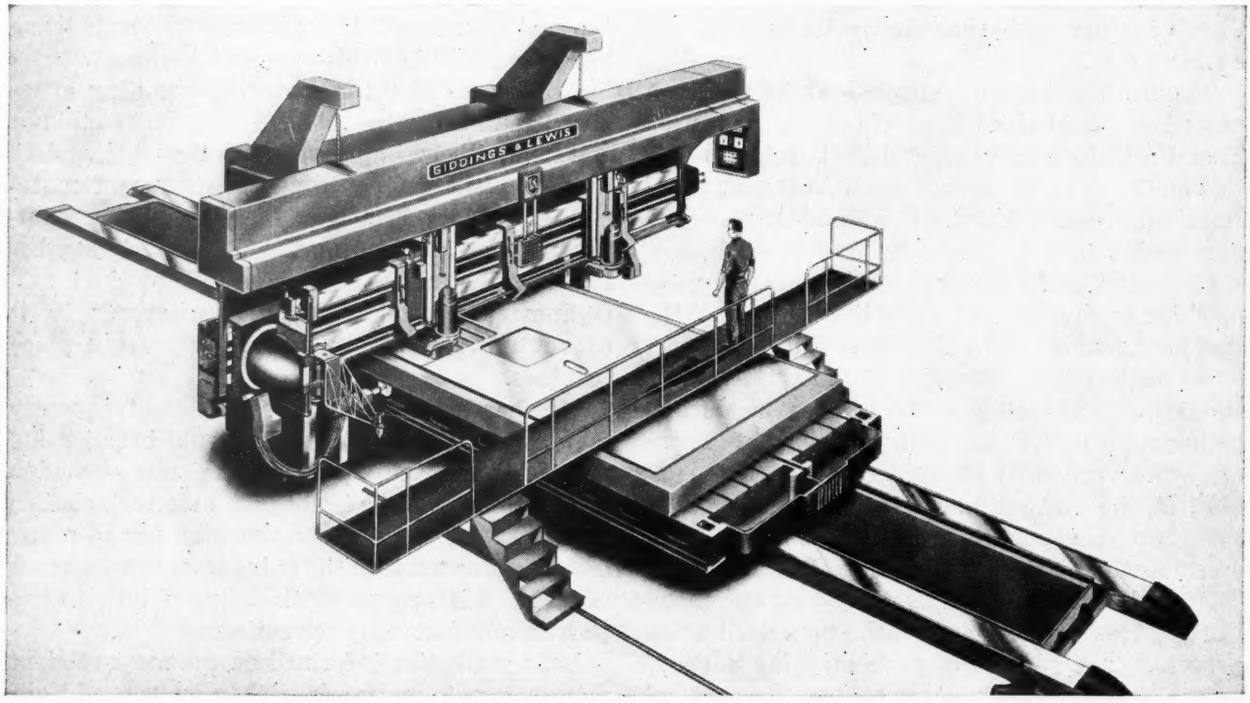


Fig. 1. "Hypro" aircraft skin milling machine of giant size developed jointly by Giddings & Lewis Machine Tool Co., General Electric Co., and Lockheed Aircraft Corporation

To obtain additional information on equipment described here, use Inquiry Card on page 253.

Equipment

Machine Tools, Unit Mechanisms, Machine Parts, and Material-Handling Appliances Recently Placed on Market

Edited by FREEMAN C. DUSTON

master pattern, while a vertical milling head cuts the surface to varying thicknesses, thus producing a "sculptured" surface that takes the place of struts, braces, ribs, and girders.

The machine operates in three dimensions with two feed motions, the feed range being from 3/4 inch to 150 inches a minute with stepless changes. A two-dimension electronic tracer control guides the longitudinal and lateral cutting motions simultaneously, while the vertical rise-and-fall cutting action controls the variations in web thickness.

Each of the three milling heads employs an Onsrud water-cooled unit, powered by 100-H.P. induction motor parts. The machine has twelve drive motors, totaling approximately 350 H.P., exclusive of eighteen motors and generators that deliver the power supply. A 20-H.P. motor drives the table, with its 100-ton load capacity, and smaller motors move the cutting heads on their guide rails. Sequence speed control is provided for the longitudinal and lateral feed motions. Both the table and the cutting heads can be operated at any selected speed.

Speed control and the steering control that guides the cutting angle are combined to facilitate operation. Other features are the elimination of trailing hoses and electrical lines through the use of a Giddings & Lewis feed reel, and a catwalk to give the operator a better view of the work and to enable him to move easily from one side of the machine to the other.

The work area is 10 feet wide by 34 feet long; clearance under cutters, 48 inches; and maximum metal removal capacity, 600 cubic inches per minute. The center and right heads have individual vertical profiling systems to operate in the plane of the table or head travel with quick-change templets. The left head is of the universal swiveling type, with automatic 360-degree profiling from templet. An angular path can be milled to dial settings, and precision measuring can be accomplished in two planes for accurate cutter setting. Automatic chip removal, mist lubricated spindle bearings and head gears, and covered bed ways are also features of the new milling machine. ——66

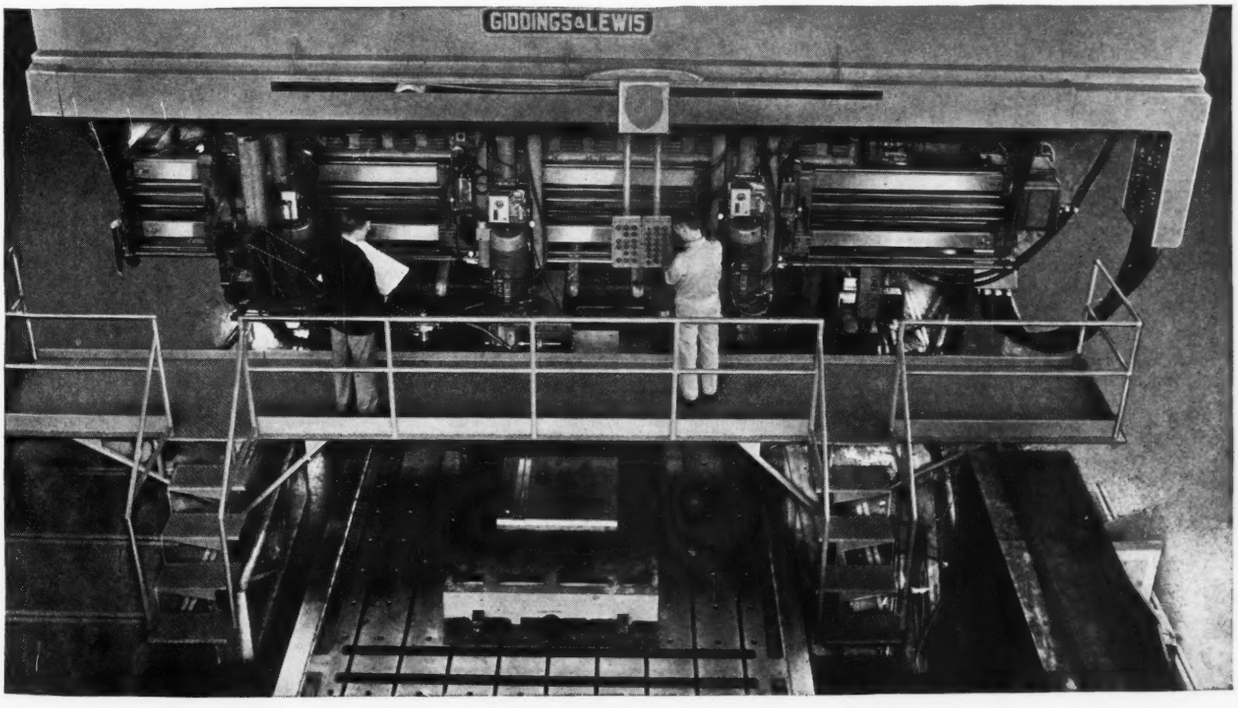


Fig. 2. Close-up view of traveling control station and operator's bridge located directly over cutter positions of machine shown in Fig. 1

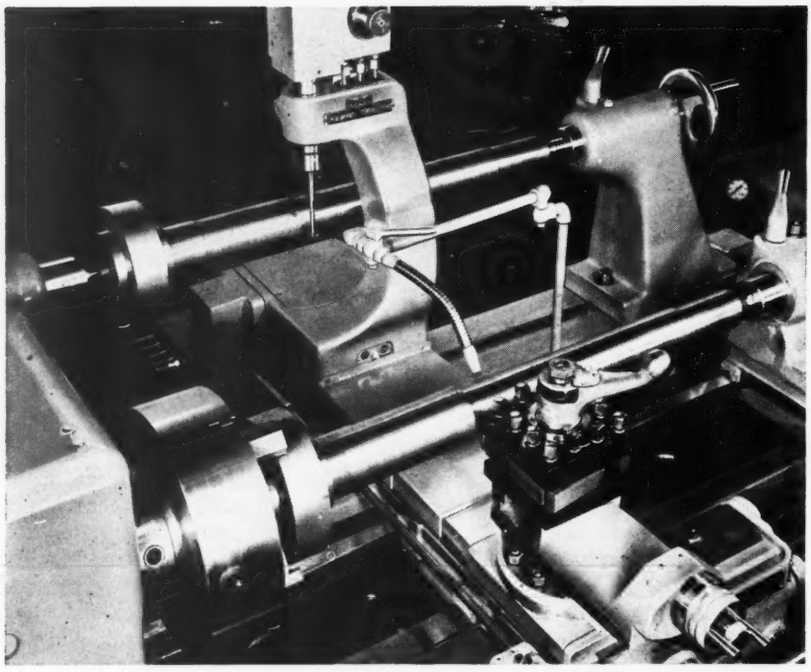


Fig. 1. "Fluid Tracer" with round master template applied to the 16-inch Model 32 Sidney lathe

Sidney Lathe Equipped with "Fluid Tracer"

The 16-inch Model 32 lathe built by the Sidney Machine Tool Co., Sidney, Ohio, is now equipped with a "Fluid Tracer." The new tracer unit is said to be unique in its simplicity and flexibility. With this equipment, the lathe can be used either for tracing from a master or for standard lathe work, including such operations as thread chasing. Engagement or disengagement of the tracer unit takes only a few seconds, and requires no changing of parts.

Either flat or round templates can be used. A clamping bar is supplied with each unit for positioning flat templates, this bar being removed when round templates are to be employed.

A front view of the lathe and tracer attachment with round template set-up is shown in Fig. 1. Flat template set-ups are shown in Figs. 2 and 3. The hydraulic clutch and brace control box which governs the longitudinal movement of the carriage is located at the end of the front ways of the lathe bed, and can be seen near the upper left-hand corner of the hydraulic power unit shown in the foreground of Fig. 3. This view also shows how the flexible tubing is held off the floor and unrolled from the hydraulic unit along a trough.

The extremely sensitive tracer head assures accurate reproductions. A valve located on the tracer head controls the rate of cross-feed. Rapid advance or withdrawal of the tool is obtained by actuating a lever on the front of the carriage. The Sidney "Fluid Tracer" is supplied with electric drive motor and control, hydraulic power unit, hydraulic control valves, template holders, and the necessary piping, tubing, and fittings. ---------- 67

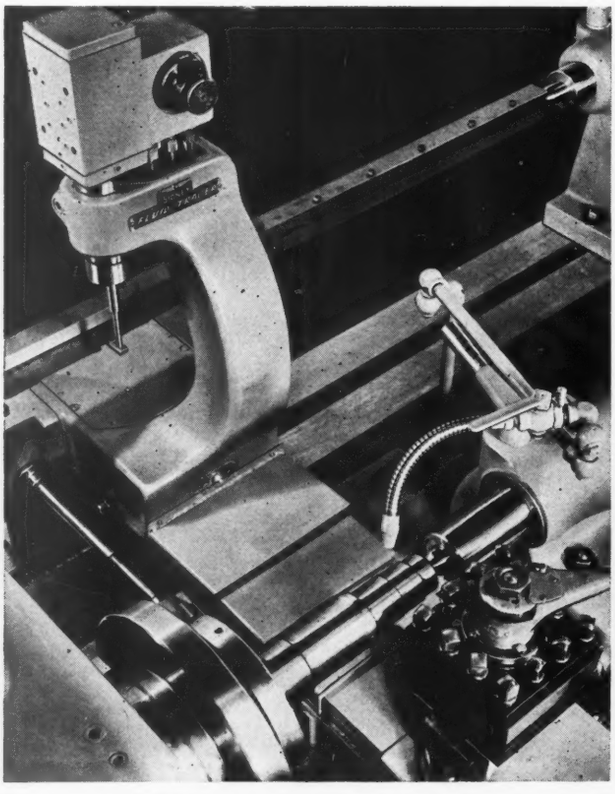


Fig. 2. Installation of "Fluid Tracer" using flat template

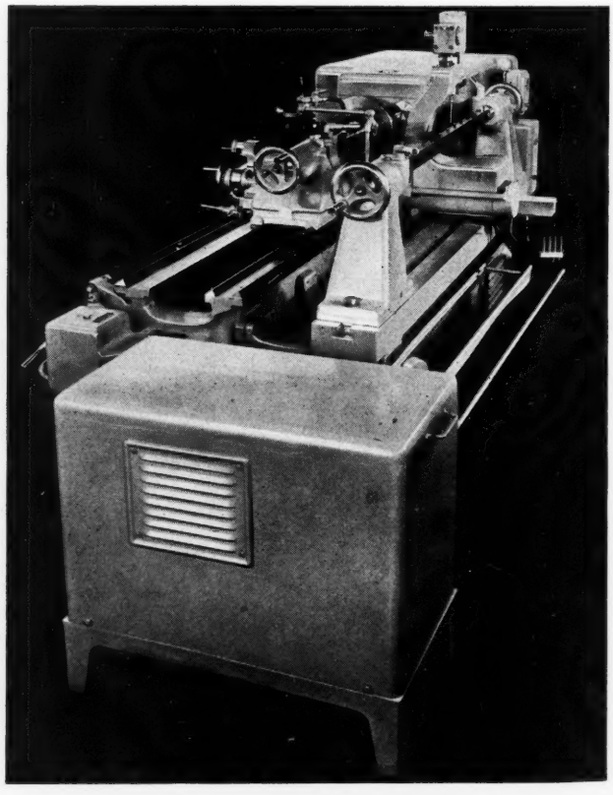
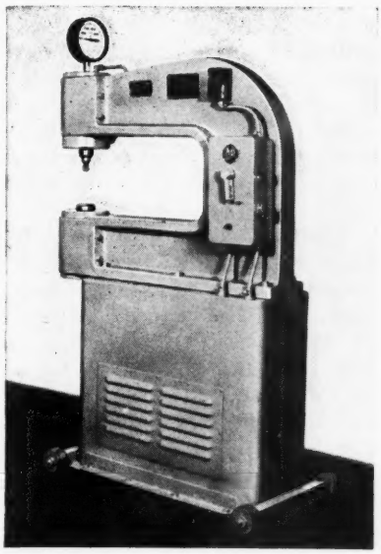


Fig. 3. Rear view of installation shown in Fig. 2

To obtain additional information on equipment described here, use Inquiry Card on page 253.



Brinell hardness tester made by Steel City Testing Machines, Inc.

Brinell Hardness Testing Machine

A hydraulically operated Brinell hardness testing machine with a throat depth of 24 inches has been made for a leading producer of armor plate by Steel City Testing Machines, Inc., of Detroit, Mich. This Model AP-1 deep-throated C-frame hardness tester incorporates several unusual features, including mounting on wheels. Thus the machine can be rolled out of the way when not in use and easily rolled back into the operating position over work on a conveyor.

The lower anvil is the top of a hydraulic piston, which rises as the load is applied, to take the pressure off the conveyor. This also tends to keep the armor plate level during the test. The anvil height is made to conform to the customer's conveyor height. The maximum vertical opening between ball penetrator and anvil is 4 inches.

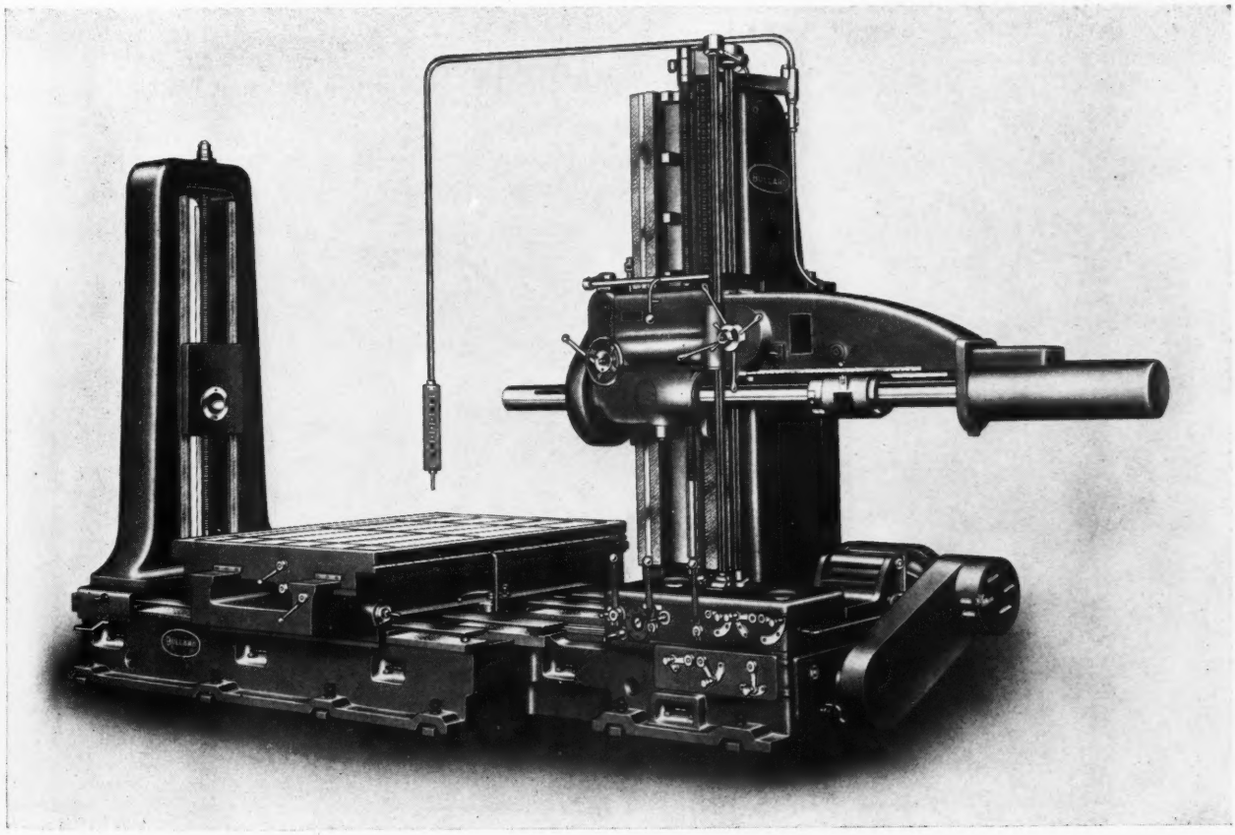
The operating cycle is controlled by a simple snap switch mounted on the side of the machine. The switch is turned on to apply the 3000-kilogram load, and off to release the load. The diameter of the impression is measured with a Brinell microscope, as in all Brinell hardness testing. The hydraulic unit is located in the base that supports the C-frame. The machine is approximately 41 inches deep by 19 inches wide, and weighs about 900 pounds. 68

Bullard Horizontal Boring, Milling, and Drilling Machine

Features developed to insure longer life and minimum maintenance costs have been incorporated in an improved four-way bed horizontal boring, milling, and drilling machine brought out by the Bullard Co., Bridgeport, Conn. This machine is being built in two sizes—a 4-inch spindle machine having twenty-four speeds varying from 8 to 1000 R.P.M., and a 5-inch spindle size having twenty-four speeds ranging from 7 to 850 R.P.M. The heavy box type four-way bed is designed to maintain a high degree of accuracy combined with a capacity for rapid production.

The four bed ways provide adequate support for the exceptionally heavy, ribbed box type saddle and table. The ways are covered by sheet-metal guards as a protection from chips and other foreign materials. Non-metallic bearing surfaces are provided for both saddle and table.

The saddle guide and feed-



Horizontal boring, milling, and drilling machine brought out by the Bullard Co.

screw are located between the inner bed ways, so that any cocking tendency due to uneven load distribution is minimized. Single-lever self-equalizing clamps acting on the outside of the outer bed ways provide maximum downward clamping pressure. Table cross-feed nuts revolve in pre-loaded anti-friction bearings, and are adjustable for wear.

Lubrication pumps provide filtered oil under pressure for gears and bearings, and the large reservoir permits ample cooling of the lubricant. A smooth positive drive for horizontal boring machine work is provided by an improved type of hydrodynamic coupling (fluid drive) and brake motor through multiple V-belts. This type of drive absorbs shock induced by interrupted cuts in heavy work. A pendent push-button control protects the operator and facilitates operation. 69

Hammond Abrasive-Belt Platen Grinder

A heavy-duty 8-inch wet abrasive-belt grinder has been added to the line of Hammond Machinery Builders, Inc., Kalamazoo, Mich. Features of this Model V8-WP machine include a new power reciprocating table with tilting work-holder and a water-cooled belt platen. The new grinder is designed for the production finishing and surfacing of ferrous, ceramic, and plastic parts. Thin sectioned parts are said to be finished without danger of becoming distorted.

Table travel is adjustable from 0 to 8 inches, and the speed of the stroke back and forth across the abrasive belt can be varied to suit the work. The tilting work-holder is designed to facilitate bringing the work to the loading, unloading, and grinding positions.

Features of the water-cooled platen make it possible for the downward pull of the abrasive belt to create a continuous film of coolant between the back of the belt and the entire face of the plate. This tends to eliminate distortion of both work and platen from heating. The machine can be equipped with a plain table or a manual reciprocating table, and can be arranged for water main connection instead of with a self-contained pump and tank. 70

"Promatic" Centerless Grinding Machine

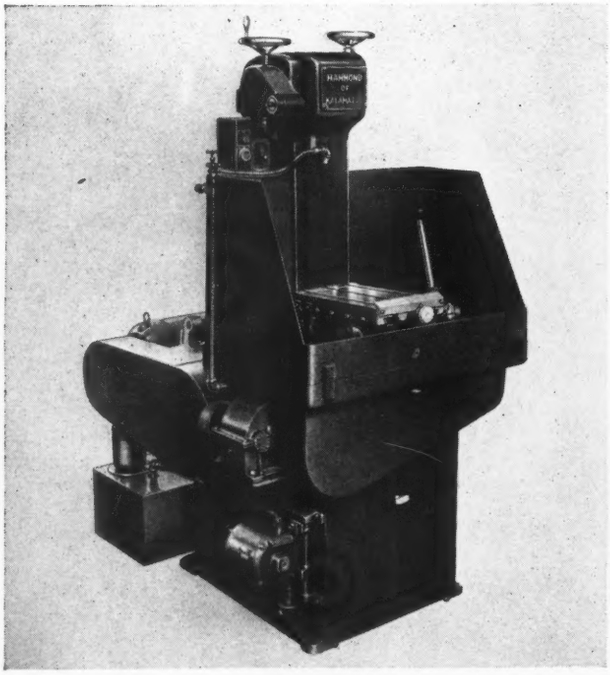
To meet the demand for a compact machine that is capable of producing an exceptionally fine finish and is within the purchasing price range of the average shop, the Diversified Metal Products Co., Los Angeles, Calif., has brought out the "Promatic" No. 1 centerless grinder. This machine has a wide range, and is especially adapted for accurate grinding of small and medium size parts, the maximum work diameter being 1 1/4 inches.

The extra heavy-duty alloy-steel spindles are mounted in pre-loaded, precision, anti-friction bearings. The grinding wheel is 14 inches in diameter, has a 4-inch face, and operates at a speed of 1600 R.P.M. A 2-H.P., 1800-R.P.M., 220- to 440-volt, 60-cycle motor is used to drive the grinding wheel. A 1/4-H.P. motor with Vari-drive permits instant selection of the correct regulating wheel speed within a range of 35 to 350 R.P.M.

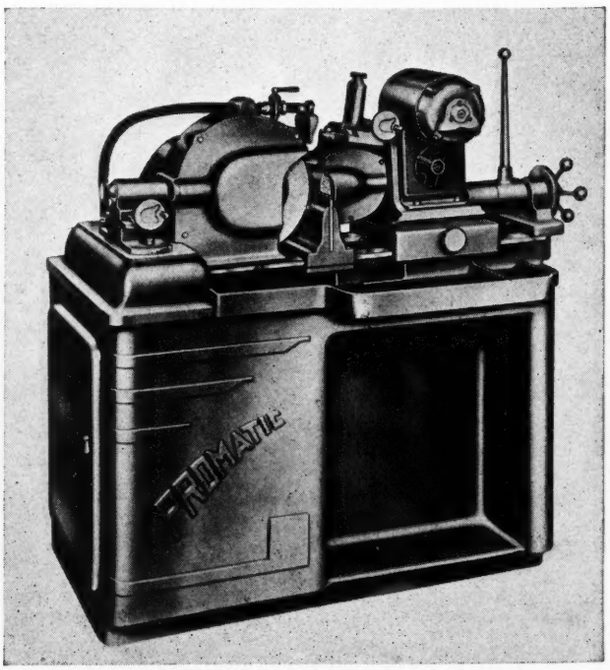
The diamond wheel-truing devices have micrometer controls and are designed for combination straight and contour wheel dressing. The machine is 48 inches long by 54 inches high by 35 inches wide, and weighs approximately 2800 pounds. 71

Diamond Compound for Polishing Carbide Dies

After intensive research and actual field testing in plants engaged in polishing carbide dies, the Industrial Products Division, Elgin National Watch Co., Elgin,



Abrasive-belt platen type grinder made by Hammond Machinery Builders, Inc.



Centerless grinding machine built by Diversified Metal Products Co.

To obtain additional information on equipment described here, use Inquiry Card on page 253.

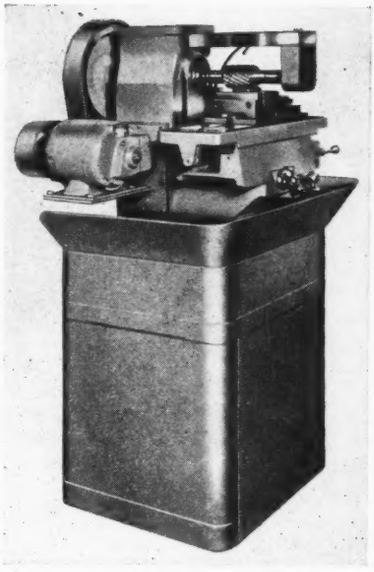
Ill., has brought out a new diamond abrasive compound prepared especially for sizing and polishing carbide wire drawing and heading dies. The new compound is an addition to the company's standard line, and will be marketed under the trade name "Dymo-C."

This compound is delivered ready for use, and requires no mixing. It is said to cut 20 per cent faster on carbide than compounds previously used. ----72

Viking High-Speed Hydraulic Milling Machine

Small parts requiring close limits and fine finish can be rapidly machined on a light production milling machine introduced by Viking Industries, Rockford, Ill. An automatic milling cycle, hydraulic feeds, small floor space requirements, and maximum rigidity are features of this machine, which is designated the Viking No. 618 hydraulic "Speed-Mill."

The machine operates within a cycle range of ten seconds to eighteen minutes, including full table travel. The time varies according to size of cut and length of travel. Hydraulic feed through valve selection is infinitely variable from 3/8 inch to 24 inches per minute over a 7-inch length of cut. A separate 3/4-H.P. motor



High-speed hydraulic milling machine made by Viking Industries

assures a positive drive to the spindle, and a standard 1/2-H.P. motor drives the hydraulic motor and coolant pump.

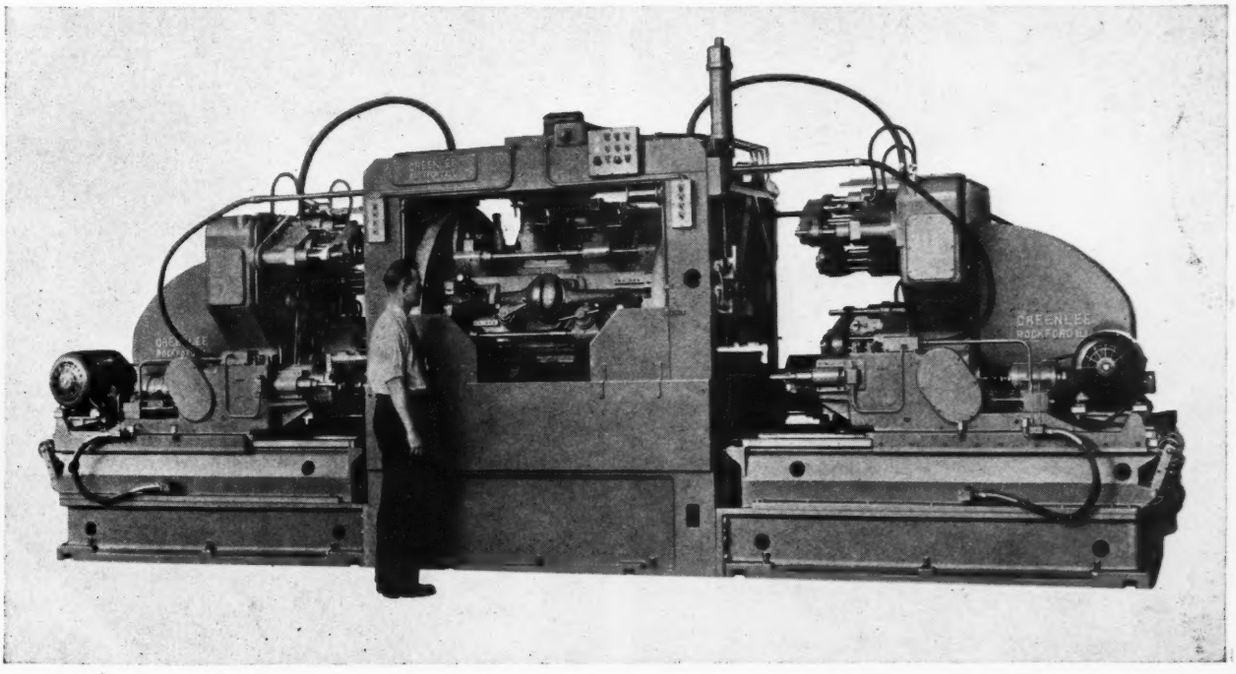
Rotary cutters up to 6 inches in diameter are employed. The cutter-spindle is rigidly supported at the outboard end through a heavy rectangular steel bar over-arm and bronze bushing. The spindle is 2 inches in diameter, and has a No. 9 Brown & Sharpe taper for mounting arbors, shanks, and adapters. Four spindle speeds of 200, 375, 625, and 975 R.P.M. provide the flexibility needed for a variety of cuts.

The table has a working surface of 6 by 18 inches, and a maximum travel under power of 8 1/2 inches. Work is raised and lowered by means of crank dials. The machine weighs approximately 1050 pounds, is 51 1/2 inches high, and requires a floor space of 30 inches by 32 inches. ----73

Greenlee Way Type Automatic Indexing Machine

A four-way, horizontal and angular, six-station automatic indexing machine was recently built by Greenlee Bros. & Co., Rockford, Ill., for machining automobile rear-axle housings, which completes thirty operations in 29.2 seconds, giving an hourly production of 123 pieces.

Two diameters are combination-bored in each end of the housings, and the ends are faced at the second station. Semi-finish-boring operations on the two diameters are completed at the third station. Tools at the fourth, fifth, and sixth stations drill, chamfer, and ream, respectively, four holes in each of the housing end flanges. Two rear heads at the fifth and sixth stations drill and tap the breather hole. ----74



Way type automatic indexing machine for operations on rear-axle housings, built by Greenlee Bros. & Co.

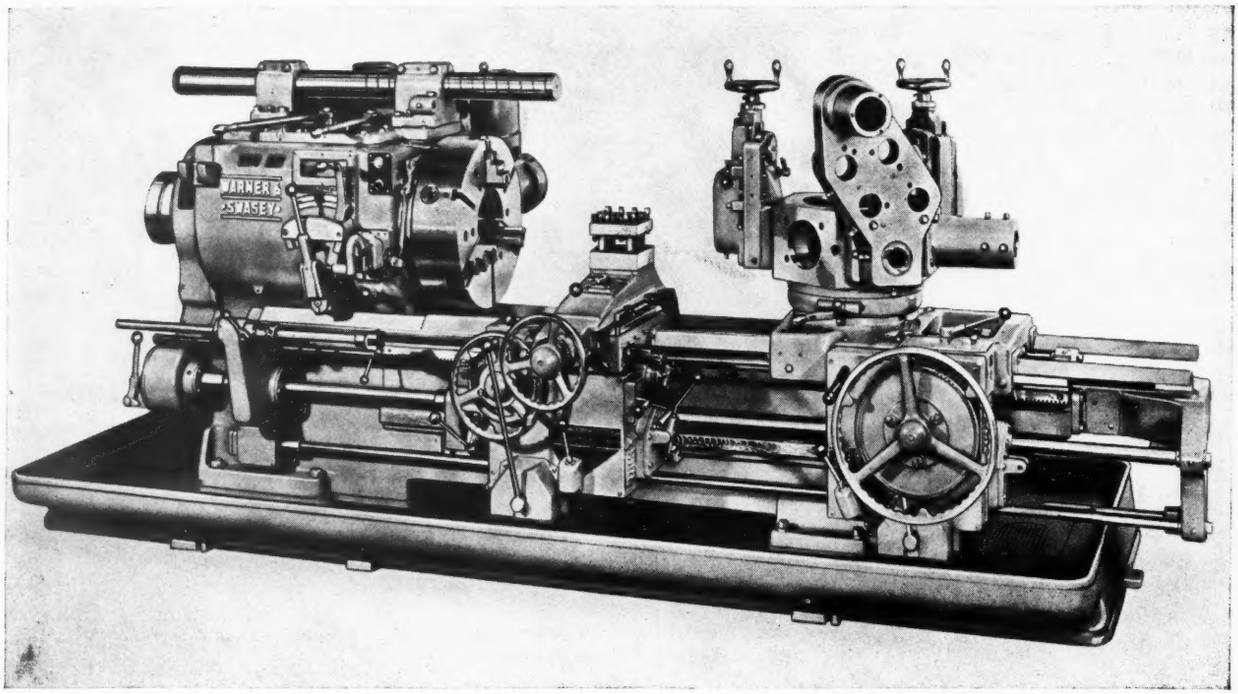


Fig. 1. Heavy-duty saddle type turret lathe of improved design, announced by the Warner & Swasey Co.

Warner & Swasey New Model Turret Lathe

A new model heavy-duty saddle type turret lathe incorporating important design changes has been added to the line of the Warner & Swasey Co., Cleveland, Ohio. The headstock of this machine has a hydraulically actuated forward and reverse clutch combined with a disc type hydraulic brake, developed to provide for faster and smoother handling of bar stock. The clutch and brake mechanism is controlled by a "forward-reverse-brake" lever, which eliminates the neutral or intermediate delay position previously used and permits fast starts,

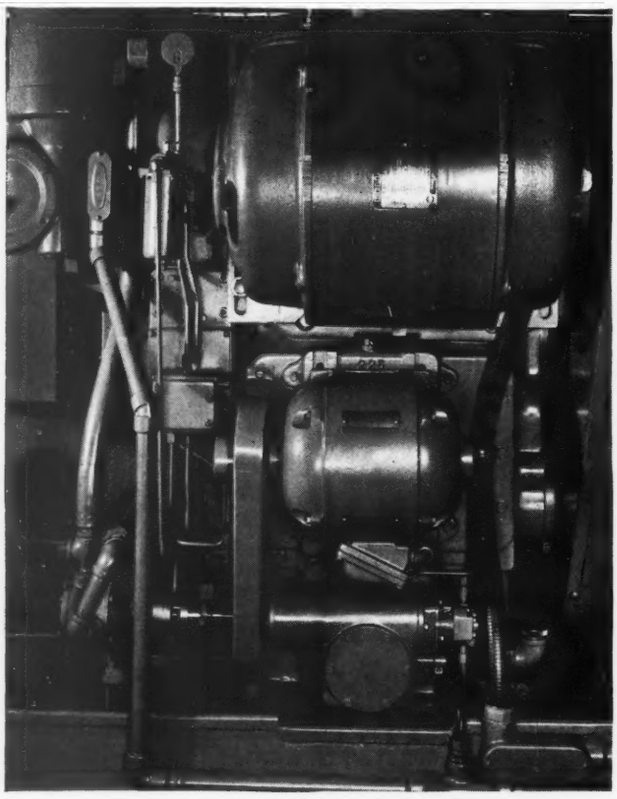


Fig. 2. Close-up view of separate motor for driving auxiliary equipment of Warner & Swasey turret lathe

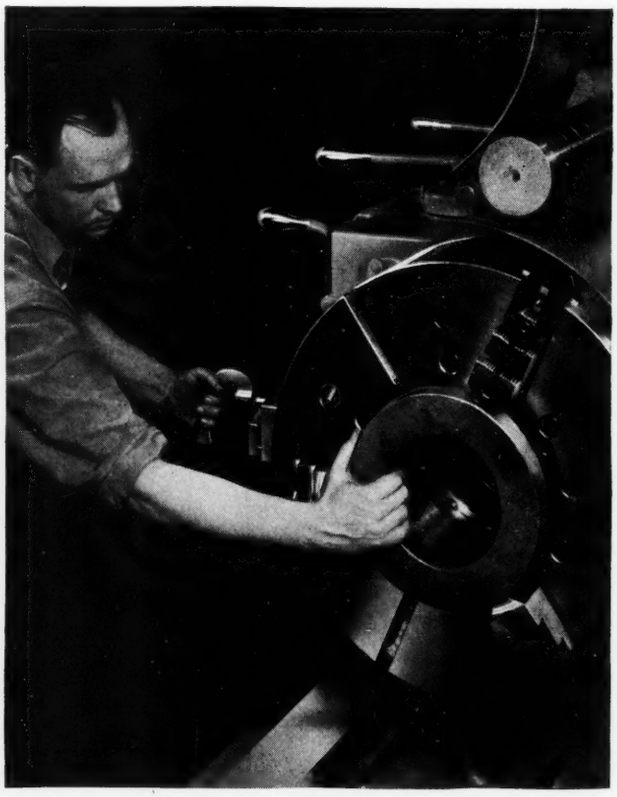


Fig. 3. Close-up view of pistol-grip control for power chuck and heavy-duty overhead pilot bar attachment

To obtain additional information on equipment described here, use Inquiry Card on page 253

stops, and reversals of heavily weighted spindles.

This new machine, known as Model 4A, is made in two sizes for handling 8- and 12-inch bar stock. Its rapid-traverse shaft has been moved to the front of the machine, which is now provided with rapid traverse to the cross-slide. A single lever serves to control rapid-traverse motion in four directions. Power for the rapid-traverse drive, formerly obtained by belt from the main drive-shaft, is now supplied by a separate 3-H.P. motor, mounted in back of the headstock. The same motor, shown in Fig. 2, also drives the coolant, hydraulic, and lubricating pumps.

Pressure in the lubricating system has been increased, and a new type high-pressure gear pump has been applied to the unit. The design of the stop roll for the hexagon turret has also been improved to provide easier adjustment and longer life. All electrical controls are now consolidated in a single box to simplify the protection and maintenance problems.

Bar feed attachments for the new machines are hydraulically operated, the same stand and feed head being used as was previously employed in the manually operated model but with effortless hydraulic actuation obtained through a control lever mounted at the top of the carriage stop rod bracket. The power chuck wrench control lever has been replaced by a more efficient pistol-grip arrangement, as shown in Fig. 3, which has a trigger interlock release for easier manipulation. All standard tools are applicable to the new model turret lathe. 75

Large Hydraulic Presses Built to Speed up Production of Farm Machinery

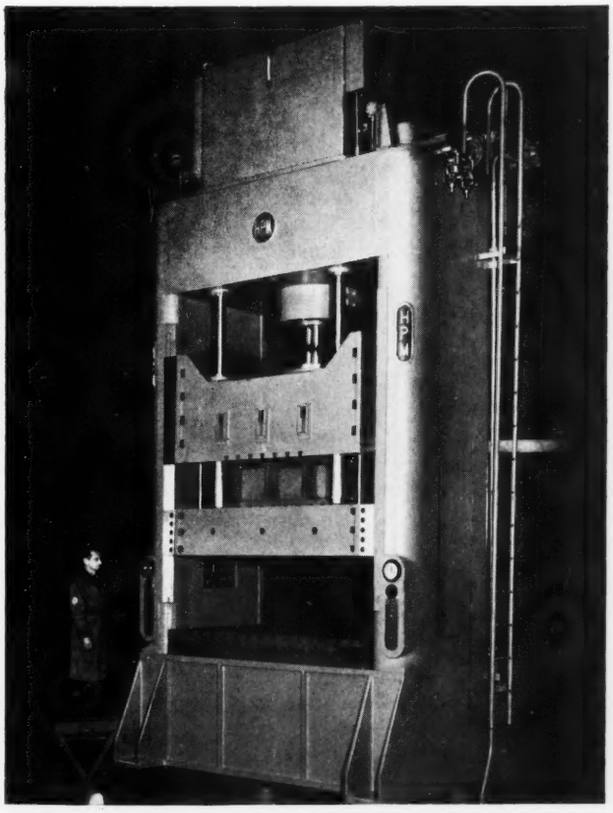
Production of drawn sheet-metal parts for harvesters and other farm machinery equipment has been substantially increased at the Massey-Harris plant at Racine, Wis., by the addition of two 400-ton "all hydraulic" presses built by the Hydraulic Press Mfg. Co., Mount Gilead, Ohio.

These large machines have a pressing surface of 96 by 60 inches, and are equipped with 150-ton blank-holders and 100-ton die cushions. The presses employ a 42-inch stroke with a daylight height of 78 inches. They are operated by "Fastraverse" hydraulic power systems manufactured by the Hydraulic Power Division of the company. 76

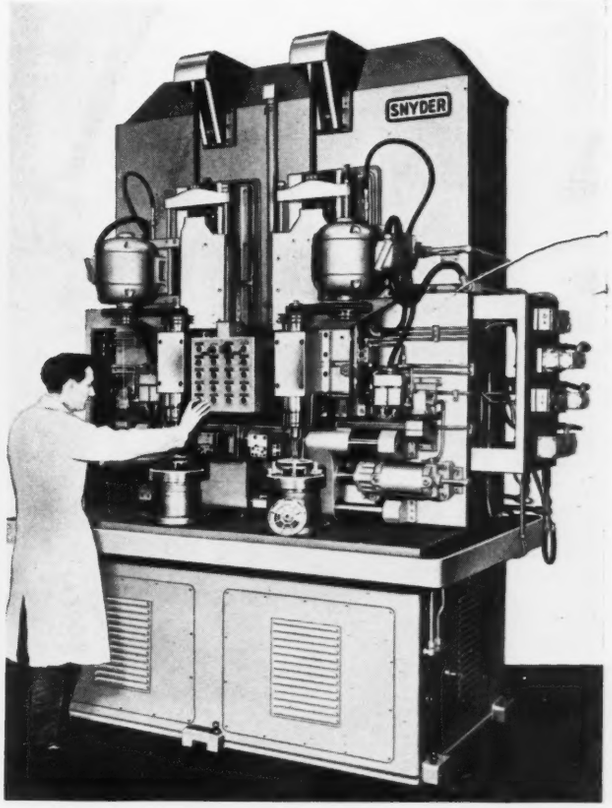
Snyder Automatic Duplex Machine for Machining Motor End Shields

Snyder Tool & Engineering Co., Detroit, Mich., has designed an automatic duplex machine for the precision boring and facing of the end shields for fractional-horsepower electric motors. The operation consists of finish turning and facing the rabbet on the outside diameter of the aluminum body and finish-boring the hub bushing, which may be either steel or babbitt. Production ranges from 210 to 338 pieces per hour.

Power is supplied by two 1-H.P., 600-R.P.M. chuck motors and two 3/4-H.P., 1800-900-R.P.M. spindle motors. The spindles are driven through V-belts, which permits variation in the spindle speeds. A spindle speed of 4778 R.P.M. and a chuck speed of 334 R.P.M. are now being used. Clamping is accomplished automatically by a spring diaphragm,



"All hydraulic" press built for the production of farm machinery by Hydraulic Press Mfg. Co.



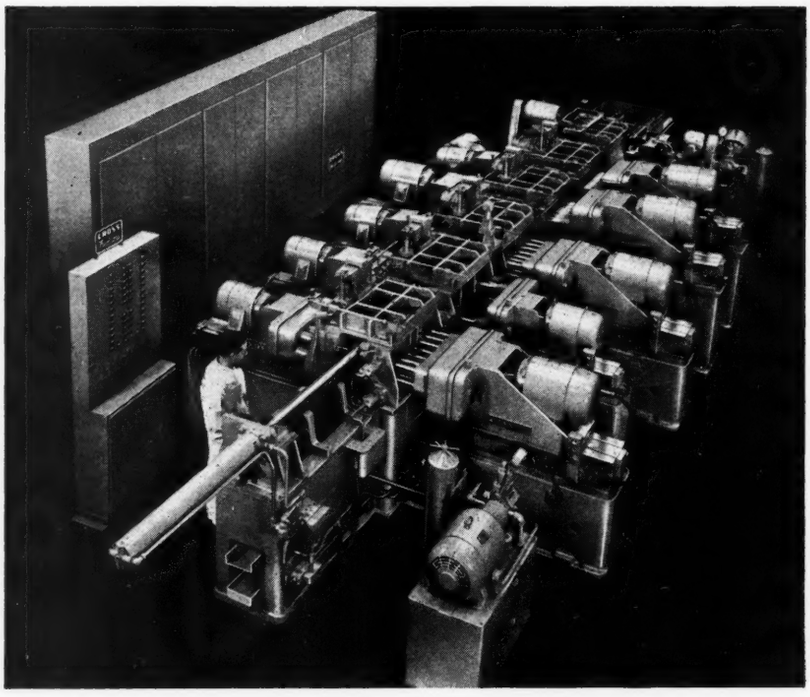
Snyder automatic duplex machine developed for rapid machining of electric motor end shields

To obtain additional information on equipment described here, use Inquiry Card on page 253.

while unclamping is by hydraulic return of the diaphragm.

Work is unloaded and reloaded at one station while work is being done at the other station. The work cycle, using tungsten-carbide tools, consists of rapid advance, feed, and rapid return of cross-slide to machine rabbet with chuck revolving; then feed and rapid return of spindle to bore bushing with only the spindle revolving. Feed rate of cross-slide is 1 inch per minute, and of spindle, 15.3 inches per minute.

The machine requires a floor space of 75 by 104 inches. Coolant is supplied from a tank at the rear, and is circulated by a separate pump and motor. Lubrication is automatic. ----------77



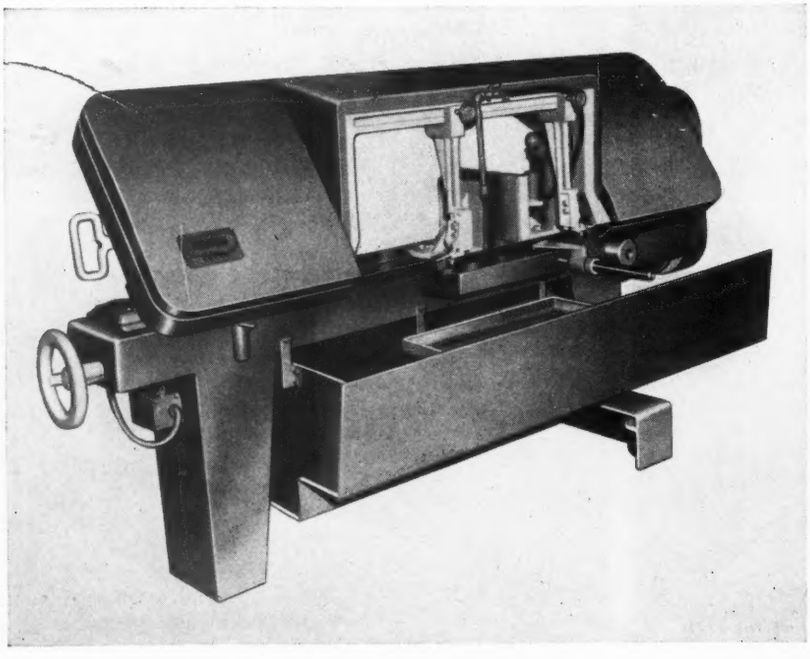
Special "Transfer-matic" built by The Cross Company, for drilling cylinder heads

Metal-Cutting Band Saw

A new metal-cutting band saw, designated the "Kalamazoo 1220," has been added to the line manufactured by the Machine Tool Division, Kalamazoo Tank & Silo Co., Kalamazoo, Mich. This machine is designed for fast, accurate production cutting of metal bars up to 12 by 20 inches and round stock up to 12 inches, and over. It is available in standard or coolant-equipped models.

Outstanding features include exceptionally rugged construction developed to maintain precision; four cutting speeds from 61 to 259 feet per minute; a unique dashpot mechanism to insure controlled, constant pressure during the complete cut; swivel, leaf type 45-degree vise for easier adjustment of cutting angles; quick, easy blade mounting from the top; and unobstructed view of work.

Standard equipment includes a 1-H.P., 220- to 440-volt motor and a stock stop-bar. The machine is 87 inches long, 26 inches wide, and has a bed height of 25 1/2 inches from the floor. ----------78



Kalamazoo metal-cutting band saw

Cross "Transfer-matic" for Drilling Cylinder Heads

A "Transfer-matic" designed to perform ninety different operations on 100 cylinder heads per hour has been built for a large automotive manufacturer by The Cross Company, Detroit, Mich. This machine performs work at eight stations, the part being loaded at the first station. At the second station, six rocker-arm bracket holes and one water-jacket hole are drilled, and sixteen stud holes are drilled to one-half the final depth.

At the third station, four of the stud holes are drilled to the final depth, the rocker-arm bracket holes are chamfered, two stud holes are reamed to serve as locating holes, and three water-jacket holes are drilled. At the fourth station, two oil-holes are drilled to one-half depth and the drilling of the remaining twelve stud holes is completed.

At the fifth station, nine stud bosses are spot-faced and twelve push-rod holes are drilled half way through. At the next station, the two oil-holes are drilled to final depth, the rocker-arm bracket holes and the first water-jacket hole are inspected automatically for depth, and the twelve push-rod holes are drilled to final depth. At the seventh station, six rocker-

To obtain additional information on equipment described here, use Inquiry Card on page 253.

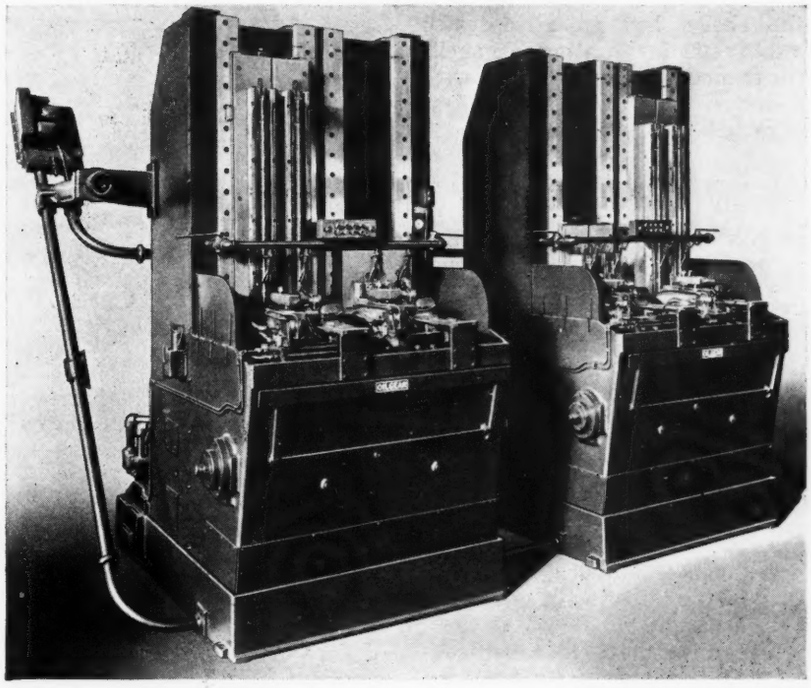


Fig. 1. Front view of twin Oilgear 25-ton double-slide surface broaching machines

shaft bracket holes and one water-jacket hole are tapped. The completed cylinder head is unloaded from the eighth station.

The parts are automatically transferred from station to station. Clamping is accomplished through hydraulic power. A circulating coolant system cleans and lubricates the taps while they are retracting. A conveyor moves chips to a central disposal point.....79

Oilgear Double-Slide Surface Broaching Machines Equipped with Automatic Chip Conveyor

Half-round and joint surfaces with tongues are finish-broached on truck engine connecting-rods and caps at the rate of 380 rods and 380 caps per hour on twin Type XD 50- by 66-inch stroke double-slide surface broaching machines built recently by the Oilgear Co., Milwaukee, Wis. Approximately 0.280 inch of stock is removed from each surface. All chips are removed automatically from the bases of both machines by means of a single Hapman rubber flight continuous conveyor driven by a 1/2-H.P., 1750-R.P.M. motor and gear reducer.

Each machine weighs 52,240 pounds, and has a normal broaching capacity of 50,000 pounds and a peak capacity of 75,000 pounds. Adjustable cutting speeds for each slide range up to 33 feet per minute. The tool-slides are 23 by 77 1/2 inches, and the work-tables 27 by 21 inches. An Oilgear Type DX-6011 two-way variable-delivery pump is direct connected to a 40-H.P., 900-R.P.M. electric motor. A new, patented work-table shuttling mechanism in a knee bracket locks and pre-loads work-tables in the broaching position to resist peak angular thrust on the tool face. Centralized push-buttons facilitate operation of the machines. The ways for the tool slides and work-tables are pressure lubricated. 80

V & O Shell Trimming Machine

The V & O Press Co., Division Emhart Mfg. Co., Hudson, N. Y., has announced the addition of a new machine to its line of shell case trimming equipment, known as the No. 986 shell trimmer.

This machine has a capacity for handling 155-millimeter shells,

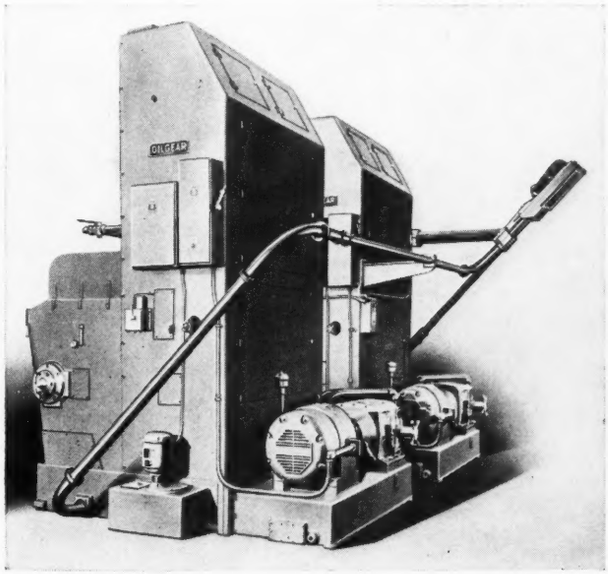
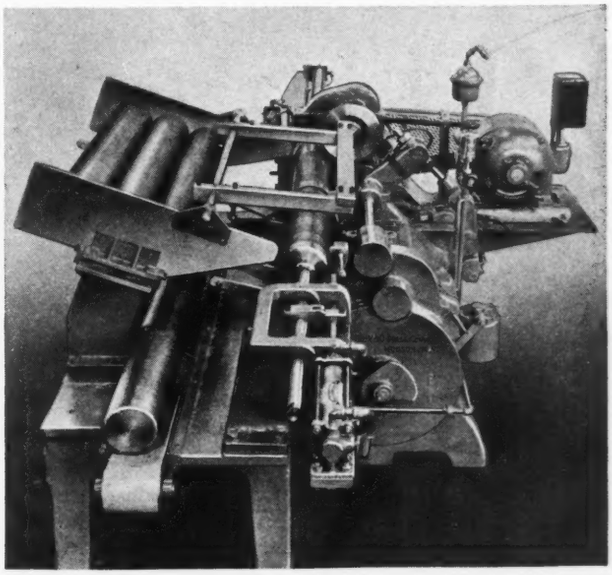


Fig. 2. Rear view of twin broaching machines showing automatic chip conveyor system



Shell trimming machine placed on the market by the V & O Press Co.

To obtain additional information on equipment described here, use Inquiry Card on page 253.

with a maximum length of 52 inches, a maximum diameter of 8 1/4 inches, and a thickness of 0.150 inch. It is equipped with an automatic chute for feeding the shells, has an air-operated mechanism for locating the shells for trimming, and is provided with a device for automatically ejecting shells on a conveyor. 81

Huge High-Precision Revolving Table Grinder for Armament Work

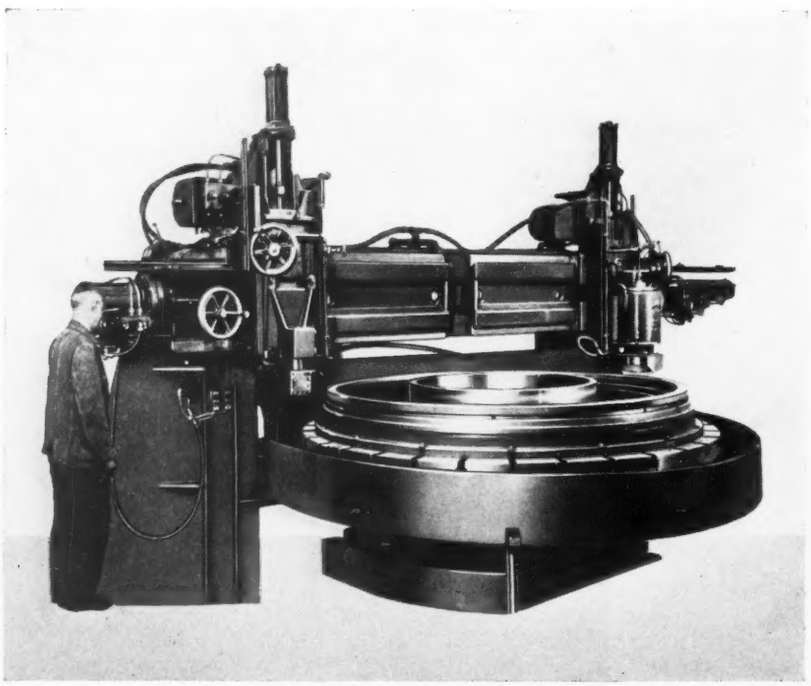
The huge 2200 Series Frauenthal grinder here illustrated was developed during World War II for armament work by A. Harold Frauenthal, Inc., Muskegon, Mich. These double-head, heavy-duty machines are of the revolving table type.

The high degree of accuracy obtained with these machines in handling large internal, external, and surface grinding work, as well as light precision boring and turning, has placed them in great demand for vital operations on big gun mounts and for machining heavy-duty oil machinery, steel mill equipment, rugged road-building machines, crushers, bending machines, and other huge production units.

Extra rugged construction, combined with a work-swing range up to a diameter of 150 inches, permits the grinding of large work consistently to tolerances of 0.0002 to 0.0003 inch on the diameter and parallelism of finished faces. Angular accuracy is held to a tolerance of less than 0.0005 inch in 72 inches for flatness, squareness, concentricity, roundness, and taper.

The table is a semi-steel casting of heavy section with deep radial ribs to prevent deflection and radial T-slots for clamping the work-piece. It is seated and securely bolted to an extra large flange on the spindle. This flange permits wide radial spacing of heavy bolts and prevents any tendency of the table to tilt under uneven loading.

The table drive is a self-contained, variable-speed, reversing unit, with a remote-control dial speed indicator. A unique push-button control permits the operator at all times to instantly increase or decrease the table speed for most efficient grinding. Handwheels for horizontal and vertical feeds are conveniently positioned so that the operator can easily control the grinding spindle heads and keep close adjustment of the grinding stroke. The extra fine feed permits extreme precision grinding. 82



High-precision revolving table grinder for armament work, developed by A. Harold Frauenthal, Inc.

Production milling machine built by the Nolan Machinery Co.

Nolan Production Milling Machine

The Nolan Machinery Co., Rome, N. Y., has placed on the market a low-priced production milling machine designed to maintain accuracy under severe working conditions. This machine is adapted for use by unskilled operators, and is regularly equipped with hand lever feed, as shown in the illustration. Automatic and screw feeds are available.

The table has a working surface of 4 by 16 inches. A longitudinal feed of 12 inches is obtained with the hand-lever or the feed-screw, while the automatic feed provides for a longitudinal feeding movement of 8 inches.

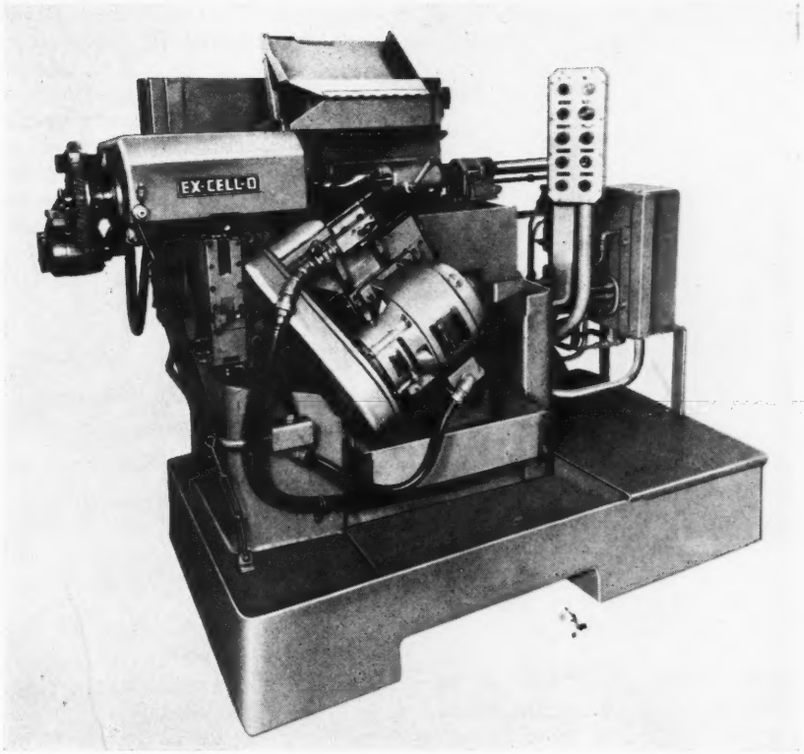
The head has a vertical movement range of 5 inches, and will accommodate cutters up to 7 inches in diameter. The over-arm is 2 inches in diameter, and the quill has a lateral adjustment of 2 inches. The spindle has a No. 40 American Standard taper nose, and is mounted on precision ball bearings. One set of single-groove pulleys provides for any standard ratio from 1 to 1 to 1 to 6. Special intermediate drive for lower speeds or multi-step cone pulleys are available as extra equipment. The machine is designed to use motors up to 2 H.P. 83

To obtain additional information on equipment described here, use Inquiry Card on page 253.

Ex-Cell-O Machine for Milling Jet Compressor Blades

The Ex-Cell-O Corporation, Detroit, Mich., has announced that a standard machine for milling the airfoil form on jet aircraft compressor blades is now available. The machining cycle of this new Style 86 precision profile miller is completely automatic, except for loading the work, pressing the start button, and unloading the work. The blades are located from the ground root form at one end and from a center in the other end. Accuracy of airfoil form is assured by the use of master cams made directly from the engineer's glass lay-outs. The coolant equipment also has automatic controls.

The new machine mills the complete airfoil form, including leading and trailing edges. An outstanding feature is that the work is supported rigidly by back-rests throughout the cutting stroke, so that the blade will not be distorted. When the start button is pressed, the headstock, tailstock, and back-rests are all clamped hydraulically. The work moves lengthwise across the cutter at an adjustable rate of feed, and at the end of every cutting stroke, the headstock, tailstock, and back-rests are unclamped and the work is indexed. The amount of movement during indexing and the total number of indexings are determined by the positioning of pins in an index plate. After the last cut, the machine comes to rest with the work raised from the cutter, and the headstock, tailstock, and back-rests unclamped. 84



Machine for milling jet compressor blades built by Ex-Cell-O Corporation

"Filmatic" Plain Hydraulic Grinding Machines

Several improvements have been made in the 10- and 14-inch L plain hydraulic grinding machines built by Cincinnati Grinders, Inc., Cincinnati, Ohio. The headstock of these machines has been com-

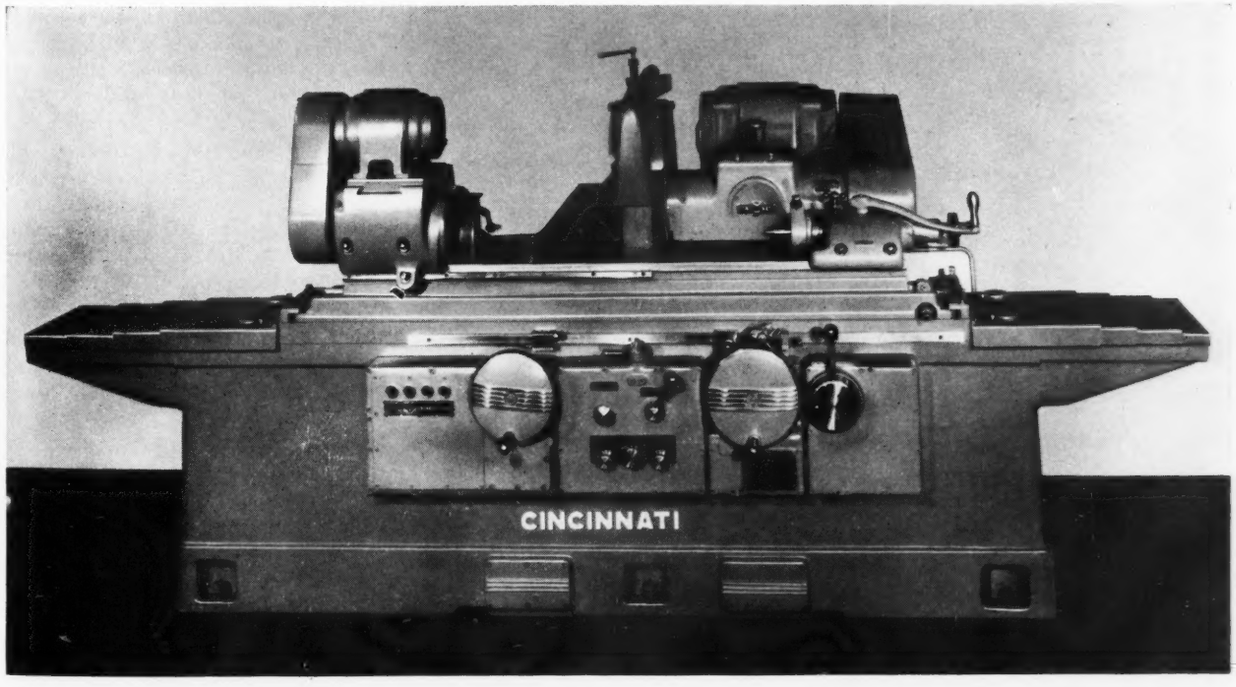


Fig. 1. Cincinnati improved "Filmatic" plain grinding machine

To obtain additional information on equipment described here, use Inquiry Card on page 253.

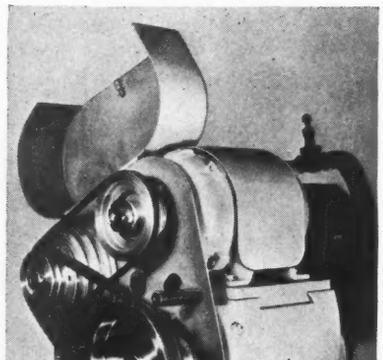


Fig. 2. Close-up view of headstock of "Filmatic" machine with belt guard open

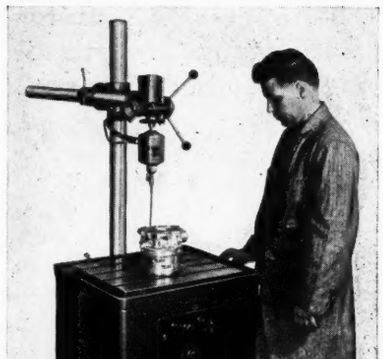
pletely redesigned, and is now powered by a 1-H.P. alternating-current motor, thus eliminating the necessity for a direct-current line to the machine. A magnetic brake is built in, and power is transmitted entirely through V-belts. An eccentric arrangement for the primary countershaft provides a means for adjusting the belt tension and changing the belt on the four-step pulley.

The bed of the new machine is 2 inches lower, the distance from the floor line to the centers now being only 39 1/2 inches. Grinding wheel collets are designed for wheels with spindle holes 12 inches in diameter to permit continued use of the wheel on smaller machines after the outside diameter has been reduced by wear. The "Filmatic" bearings for the grinding wheel spindle are self-adjusting for every grinding condition, and have been developed to run for years without maintenance. 85

Electro Arc Metal Disintegrators

The Electro Arc Mfg. Co., Detroit, Mich., has brought out a new line of metal disintegrators with several improved features. Included in the improvements are electronic control without tubes; head designed for highest possible cutting speeds; and solenoid-actuated downward movement of spindle, which assures steady contact with metal at all times, regardless of position of operating head.

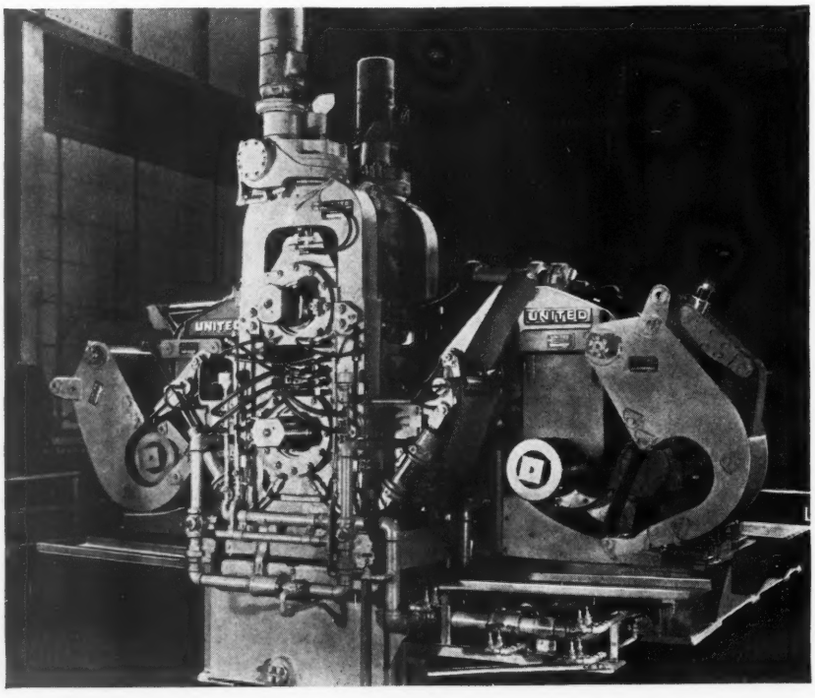
With the new units, it is possible to disintegrate a 1/8-inch drill, 2 inches deep, in 1 1/2 minutes, and a 27/64-inch reamer, 1 1/4 to 1 1/2 inches deep, in 2 minutes; to cut a 3/16-inch hole through 3/32-inch deep hardened steel (62 Rockwell) in 10 seconds; and to disintegrate a 1/4-20 tap 7/8 to 1 inch deep, in 1 minute, and a 1/2-13 tap, 1 5/8 inches deep, in 4 2/3 minutes. 86



Metal disintegrator of new line brought out by Electro Arc Mfg. Co.

All-Purpose Narrow Strip Cold-Rolling Mill

To meet the need for a small, compact, inexpensive, and versatile mill for the cold-rolling of narrow, thin strip, the United Engineering & Foundry Co., Pittsburgh, Pa., has developed the completely integrated "Package Mill" shown in the accompanying illustration. Each unit of this machine is furnished with roller-bearing mounted rolls, recirculating coolant system, mill guides, tension reels, belt wrappers (if desired), strippers, and drives, all mounted on a fabricated base, which also serves as a coolant and lubricant reservoir. All drive motors are mounted on the single fabricated base.



All-purpose strip rolling mill developed by the United Engineering & Foundry Co.

The "Package Mill" comes in three sizes, and is designed to roll copper, brass, aluminum, and low-carbon, high-carbon, and stainless alloy steels at speeds of 500 to 2000 feet per minute, starting with thicknesses of 0.030 to 0.050 inch and finishing to 0.002 to 0.004 inch.

The mill can be furnished either for one-way rolling or for reversing service. It can be equipped with motorized or hand screw-downs and with either sleeve type or collapsing mandrels. The collapsing mandrels can be had with

To obtain additional information on equipment described here, use Inquiry Card on page 253.

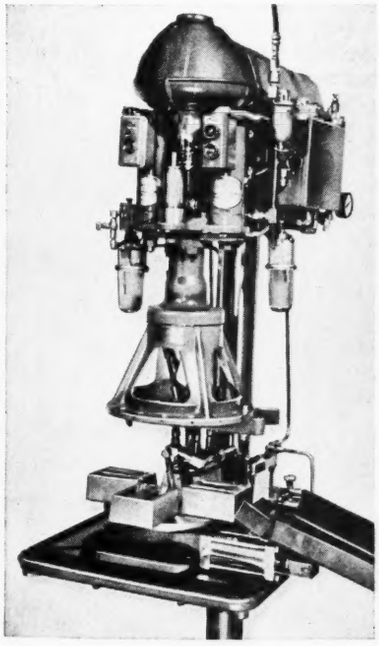
or without grippers. Auxiliary equipment for tight winding of coils before cold-rolling is also available if back tension is desired on the first pass. 87

Air-Controlled Tapping-Drilling Machines

The Beckett-Harcum Co., Wilmington, Ohio, is now manufacturing high-production tapping and drilling machines which can be equipped with automatic, air-controlled, multiple-spindle heads and index-tables. These versatile, low-cost tapping and drilling units are designed to meet customer's specific production requirements.

With these machines, multiple tapping can be performed directly from a multiple drill head without lead-screws or clutches. A very light air pressure permits the taps to provide their own lead, there being no forcing of the tap. Multiple tapping is accomplished with a special high-reversal motor, which reverses the taps when they reach the desired depth. By switching off the motor reversing control, drilling operations may be performed. The same fixtures used for drilling can also be used for tapping by removing the drill bushings.

Various types of index-tables or shuffleboard work feeders may be supplied to suit job requirements. The index-table is electrically interlocked with the spindle stroke.

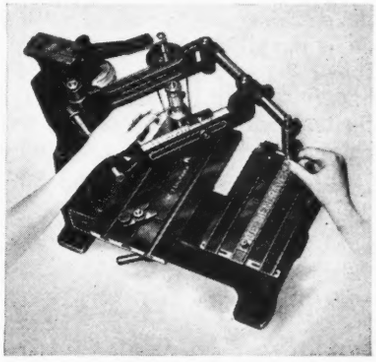


Tapping-drilling machine manufactured by the Beckett-Harcum Co.

Other features include automatic lubrication of taps and drills by an atomized oil film applied by an air blast, chips are blown clear and taps and drills simultaneously lubricated, light work can be air ejected from the fixture, and operation can be either fully automatic or single cycle. A foot switch is supplied for single-cycle operation. 88

Improved "Preis-Panto" Engraving Machine

An improved "Preis-Panto" engraving machine has been brought out by the H. P. Preis Engraving Machine Co., Hillside, N. J. This machine, designated Model UE-3, is constructed to provide exceptional strength with a minimum

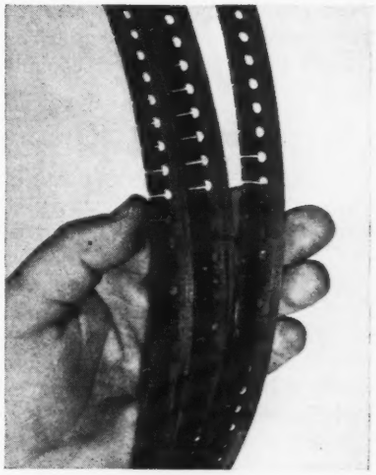


"Preis-Panto" engraving machine of improved design

of bulk and weight. The pantograph arms of cut-away design give the operator a full view of the work, as may be seen in the illustration.

Pantograph ratio adjustments range from 1.7 to 1 to 7 to 1 and are made on cylindrical sliding members with improved precision markings. Improved construction enables the operator to engrave raised or sunken lettering with maximum precision in unhardened alloy tool steel, as well as in other metals and plastics. The adjustable copy table holds either metal or molded plastic letter masters. A forming guide may be used for engraving concave or convex surfaces.

The precision ball bearing spindle has a cam-actuated drop lever for raising or lowering the engraving cutter through a range of 5/32 inch by means of screw adjustments graduated to 0.001 inch. 89



"Line Grind" band developed for inside, outside, and contour grinding of hardened metals on the DoAll "Contour-matic"

"Line Grind" Band for DoAll "Contour-matic" Machine

The DoAll Company, Des Plaines, Ill., has introduced a new "Line Grind" band for use on the "Contour-matic" band machine. This combination of continuous band cutting tool and machine is adapted for precision vertical grinding, taking inside, outside, and contour cuts in hardened metals. The new grinding band is designed to perform a wider range of work with respect to depth and height of cut, as well as contour shaping. It consists of a tough alloy band on which cubical molded abrasive matrices are welded. In its cutting action, there is an equalized balance between bonding and abrasive grits, which provides for exposure of new abrasive at a uniform rate.

The "Line Grind" band is manufactured in two types and in two grit sizes to meet the requirements for cutting and grinding many different types of hardened materials. One band, made of aluminum oxide, is recommended for grinding heat-treated alloy steels, heat-resistant steels, and wear-resistant non-ferrous alloys. The other type, made of silicon carbide, is recommended for grinding and cutting such materials as glass, quartz, marble, granite, etc.

These bands are intended specifically for use on the "Contour-matic" machine, as this machine has the features necessary for the

most efficient performance of the new band, such as vernier-controlled table feed; flood coolant; maximum rigidity; and a variable speed range of 5000 to 6000 feet per minute. 90

High-Speed "Unionmelt" Welding Machine

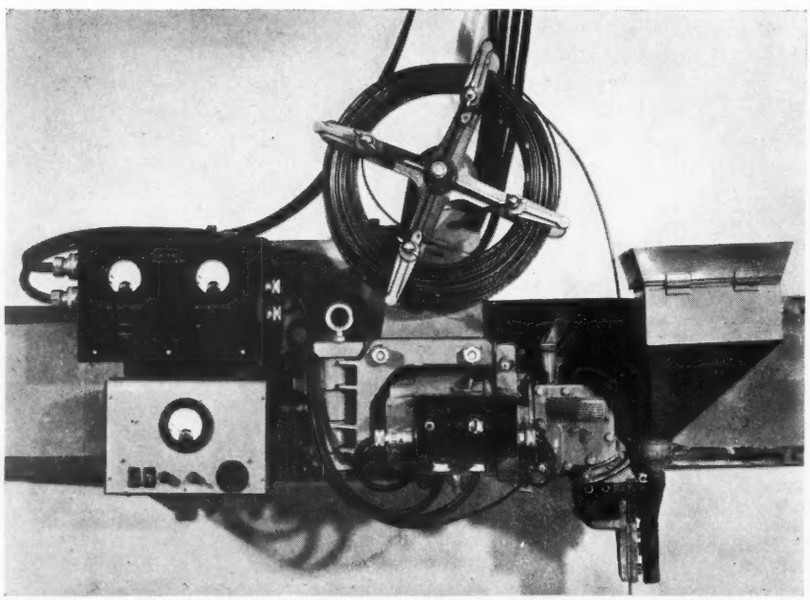
Uniform welding of straight-line seams in light to heavy plate can be done at high speeds with the UE-48 welding machine recently designed by Linde Air Products Co., Division of Union Carbide and Carbon Corporation, New York City, for "Unionmelt" welding in permanent production installations. This machine consists of a new Linde CM-48 side beam carriage, a UE welding head, a small rod reel, a "Unionmelt" feed hopper, and controls. The equipment is mounted on the steel frame of the carriage, which rides on a cold-rolled steel track. A DS "Unionmelt" welding head can also be used with this carriage, the machine then being designated the DS-48.

The control mechanism can be set to suit the welding conditions for a particular job before the machine is put into operation. The welding current, the carriage speed, the welding voltage, and the "Unionmelt" material flow can all be adjusted before welding is begun.

An inherently accurate electronic governor controls the speed of the carriage. This control permits a stepless speed range of from 3 to 200 inches per minute. The rate of speed can be preset by a meter, and the carriage will move immediately at that speed when started. The speed rate can also be changed while the carriage is in motion.

After the controls are adjusted for the desired welding conditions, the operator switches the current on and the machine then proceeds to weld without further attention. This frees the operator to unload and load the welding jig, and thus reduces human error and effort, resulting in the production of identical welds.

A wide variety of work can be handled with the new machine. Metal from 16 gage to 1 1/2 inches thick can be welded with a single pass. The head can be positioned at right angles to the track or parallel with it, as shown in the illustration. It can be adjusted to make any type of butt or fillet weld. A large reel, holding 150-pound rod coils, can be used in place of the small reel shown.....91



"Unionmelt" welding machine developed by Linde Air Products Co. for welding uniform straight-line seams in light to heavy plate on permanent production installations

Ettco-Emrick High-Speed Sensitive Tapping Machine

The Ettco Tool Co., Inc., Brooklyn, N. Y., has developed a high-speed sensitive tapping machine that can be operated by using foot or air pressure. The machine is built to use either single-spindle tapping units or multiple heads with provision for quick change-over from one job to another.

High-speed sensitive tapping machine announced by Ettco Tool Co., Inc.

No special skill is required in operating the machine. Tapping action is controlled through an adjustable pull spring inside the column. Whenever the foot-treadle is depressed, this spring feeds the tap into the work, thus providing protection against tap breakage or faulty threads.

Two oil tanks are provided; one, cast in the head, employs gravity feed for light lubrication, while the other, built into the base, supplies the pump when a steady flow of oil is required. A built-in stripper plate permits the use of simple work-holders. It also holds lubrication tube and brush.....92

Bench and Floor Stands for Light-Duty Flexible-Shaft Grinders

The Spring Specialty Co., Maywood, Ill., has placed on the market a line of universal bench and floor stands for small flexible-shaft grinders that will support machines weighing up to 15 pounds. These stands serve to

To obtain additional information on equipment described here, use Inquiry Card on page 253.

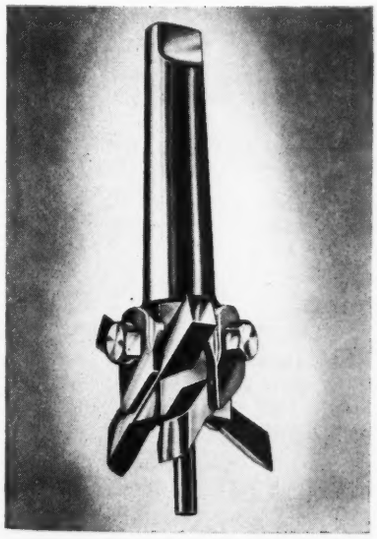
hold the grinders and accessories off the bench and facilitate proper tool approach to the work.

Both the overhead spring-suspended balancer type and the swivel-head pedestal type stands of this line are designed to eliminate torque and drag on the spindle. The floor models are mounted on ball-bearing rubber-tired casters. The bench models can either be clamped to the bench or simply placed on it. All stands are adjustable for height, revolve freely, and have tool trays.....93

Clark Three-Blade Hole-Cutting Tool

Accurate, finished holes can be produced in a single operation with a new three-blade adjustable hole cutter made by the Robert H. Clark Co., Beverly Hills, Calif. This tool cuts equally well on steel pipe, stainless steel, boiler plate, hard fiber, and other materials. It has replaceable cutter blades that are easy to sharpen and set.

The body of the tool is made of specially selected heat-treated steel and holds the high-speed steel blades, which are set 120 degrees apart. Pilots are removable to permit the use of lead drills. The complete line of these tools has a capacity range for cutting holes from 5/8 inch to 5 inches in diameter in sheets up to 1 inch thick. Two models are especially designed to cut clean holes through curved surfaces of pipe, tanks, and cylinders. 94



Three-blade hole-cutting tool placed on the market by the Robert H. Clark Co.

Adjustable boring head brought out by the Maxwell Co.

Maxwell Adjustable Boring Head

A larger body and tool-block made of heat-treated alloy tool steel, with the tool-block accurately dovetailed into the body, are features of an improved adjustable boring head announced by the Maxwell Co., Bedford, Ohio. The new adjustable boring head is designed to handle both rough and finish operations on boring, milling, and drilling machines, as well as automatics. It is small, compact, easily inserted and quickly positioned.

The "Mastur Series 50" boring head illustrated has been designed to replace the No. 5 head, while retaining its operating characteristics. Body width has been increased to give greater rigidity, support the dovetail, and permit the tool to take heavier cuts at higher speeds.

The adjusting head is graduated in fifty divisions to provide readings in thousandths, and the tool body contains graduations to permit vernier readings of 0.0002 inch. The tool-steel adjusting screw is hardened before the threads are ground to assure maximum life and accuracy.

The head has a 3/8-inch minimum capacity with forged high-speed steel bit, and a 7-inch capacity with alloy steel bar using square bit. Shanks available for use with this model are Nos. 2, 3, and 4 Morse; 7, 9, and 10 Brown & Sharpe, and 1-inch straight. In addition, the tool can be furnished with cutters having cemented-carbide tips. 95

"Cro-Hone" Wet Type Pressure-Blast Machine

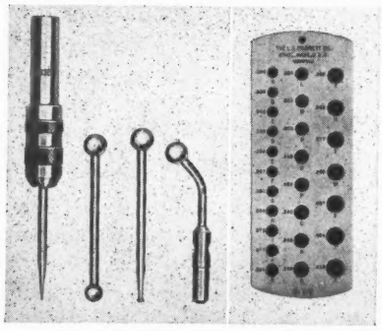
The Cro-Plate Co., Inc., Hartford, Conn., is manufacturing an improved "Cro-Hone" pressure-blast machine of the wet type. This is a low-cost, self-contained, machine developed for high-speed deburring, descaling, stock removing, and general surfacing operations. It uses the basic technique of wet blasting to greater advantage by increasing the velocity with which the wet abrasive mixture is forced into contact with the work.

The power and accuracy of the abrasive blast can best be judged by the fact that it will bore an accurate 3/16-inch diameter hole in a piece of 1/2-inch thick plate glass in thirty-eight seconds, operating at normal shop pressures of from 80 to 120 pounds per square inch.

Mechanical, knee actuating valves and controls are located within easy reach at the front of the cabinet, and a large, clear-view window enables the operator to watch the progress of the work. The unit is constructed of No. 304 stainless steel, and copper tubing is used throughout to avoid corrosion of the equipment and work. Installation requires only one 1/2-inch water connection and one 1/2-inch air connection. 96

Wet type pressure-blast machine manufactured by the Cro-Plate Co., Inc.

To obtain additional information on equipment described here, use Inquiry Card on page 253.



(Left) New Starrett "wiggler" and accessories. (Right) Starrett letter-size drill gage

Starrett "Wiggler" and Letter-Size Drill Gage

The "wiggler" and accessories shown at the left and the letter-size drill gage seen at the right in the accompanying illustration are recent developments of the L. S. Starrett Co., Athol, Mass. The additional points and attachments provided with the "wiggler" make it widely adaptable to precision work. The attachments are clamped in the shank by a ball swivel joint, which permits adjustment to true concentricity or to any angular position.

With the sharp point, working centers for jig and tool work or for vertical milling operations can be quickly and accurately located. Spring tension on the ball joint permits guiding the point to a true concentric position, so that the work can be brought into perfect alignment with the machine spindle. The spring tension can be varied by an adjusting screw on the back of the shank.

The ball contact is useful in locating work by first bringing the 0.250-inch diameter ball against a slot, hole, shoulder, or end and then indexing the work to the desired position relative to the spindle. Another point has a small disc, 0.100 inch in diameter, at the end, which can be used in confined areas, such as slots and shallow holes.

Letter-size drills can be quickly and conveniently checked with the new drill gage, shown in the view at the right. Twenty-six gaging holes are provided, giving corresponding drill sizes from "A" through "Z," with decimal equivalents from 0.234 inch diameter through 0.413 inch diameter. The gage is approximately 5/64 inch thick by 2 5/16 inches wide by 6 1/4 inches long. It is hardened and ground, has a bright finish, and is thoroughly tested after hardening. ---------- 97

New Translucent Drawing Reproduction Paper

A tough, durable, and highly translucent new drawing reproduction paper is being distributed by the Eastman Kodak Co., Rochester, N. Y. This "Kodagraph" autopositive paper is designed to meet exacting requirements in the drawing copy field. It is coated with the same emulsion used on regular "Kodagraph" autopositive paper. The new paper, however, is considerably tougher, and will withstand longer and rougher handling without tearing. Also, drawing changes can easily be effected, the lines being readily erased when moistened.

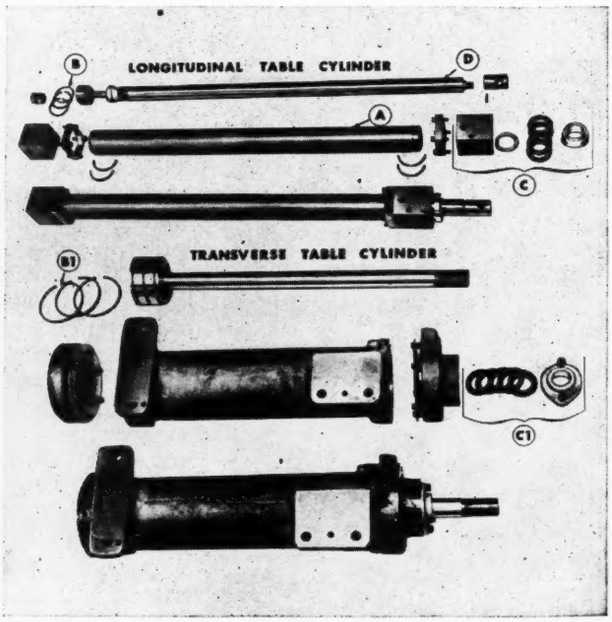
This paper can be handled on familiar reproduction equipment and in ordinary room light. It results in black-line prints from original drawings.

As a result of its greater translucence, blueprints and direct process prints can be turned out at rates up to 30 per cent faster than has been possible with previous papers. Details printed on the new paper can easily be read through the back of the sheet. As a result, reverse-reading intermediate prints are easy to work on. This paper will be supplied in standard roll and sheet sizes up to 42 inches wide. ---------- 98

Improved Hydraulic Equipment for DoAll Surface Grinders

Precision surface grinders for tool-room and production work made by the DoAll Company, Des Plaines, Ill., now have all automatic table movements hydraulically controlled through cylinders.

"Kodagraph" translucent autopositive paper brought out by the Eastman Kodak Co.



Improved hydraulic cylinders and accessories developed for DoAll surface grinders

To obtain additional information on equipment described here, use Inquiry Card on page 253.

The tables are not connected in any way with manual feeds, and even the transverse travel, or indexing, is hydraulically controlled. After an exhaustive test, the company recently adopted a new type hydraulic cylinder and piston assembly to power the tables of its hydraulic surface grinders.

On the hydraulic longitudinal table drives, the brass cylinders previously used have been replaced with precision-honed steel cylinders, as shown at *A* in the illustration. These cylinders are designed to give much longer life. Where Neoprene cups were formerly used, the new piston assembly includes three matched automotive type piston-rings *B*.

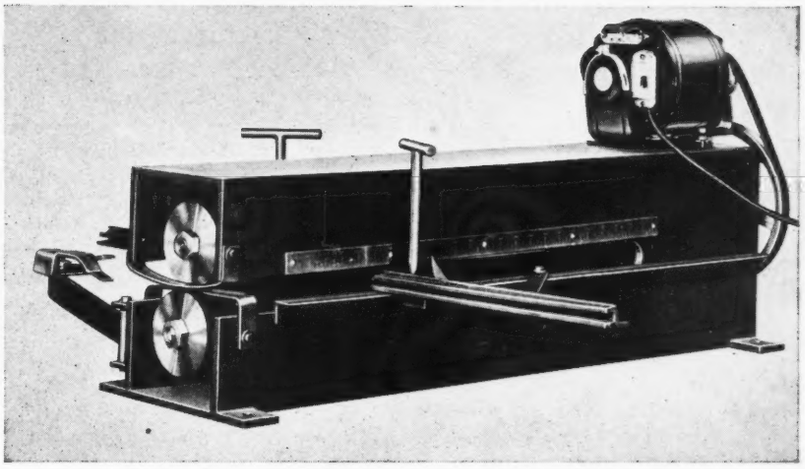
These changes provide smoother table feeds, and will practically eliminate maintenance on this assembly. The packing gland has been further improved by changing from a fixed to an adjustable type, as shown at *C*. The cylinder drive-rod *D* is a floating type, which allows the table to ride on its scraped ways without interference from the drive.

The saddle or cross-feed table movement is also completely hydraulic, and uses the same automotive type piston-rings, as shown at B_1. The cross-feed cylinder C_1 is so arranged that it can be repacked without dismantling the grinder. Through a design change in the combination valve, it has also been possible to reduce the operating pressure by approximately 30 per cent, resulting in longer life for all parts of the hydraulic system, and smoother, quieter operation. ---------- 99

Wilder Portable Metal-Slitting Machine

The Wilder Mfg. Co., Monterey, Calif., has recently introduced a metal-slitting machine adapted for use in small shops having insufficient room for a large shear, and for large shops that have too much work for their heavy shears. It can also be used to advantage on the site of construction jobs to reduce trucking and labor costs.

The machine is made in two models to handle mild steel up to 16 or 20 gage. It is adapted for slitting sheets or coils for gutters, flue pipe, skylight bars, strip stock for roll forming, and similar work. Two or more sheets of the lighter gages of aluminum can be cut at a time. The 27-inch throat depth permits cutting to the center of a sheet 4 feet wide, of any length. ---------- 100



Portable metal-slitting machine built by Wilder Mfg. Co.

Schaublin Multi-Purpose Precision Milling Machine

Carl Hirschmann Co., Manhasset, N. Y., is introducing in this country a multi-purpose high-precision milling machine built by Schaublin, Ltd., of Bevilard, Switzerland. The new machine, designated the Type SV 12, was originally developed to meet the precision and speed requirements of the tool-room, where a wide work range capacity is necessary with low accessory cost. It has had a parallel development as a production machine, and special devices, including an automatic feed, are available for such work.

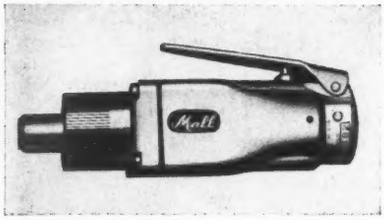
Schaublin high-precision milling machine introduced by the Carl Hirschmann Co.

The fixed rectangular table has a working surface of 17 23/32 by 7 7/8 inches, three 7/16-inch wide T-slots, and a vertical inclination of plus or minus 5 degrees. The inclinable rectangular table has a working surface of 11 by 6.3 inches and two 7/16-inch T-slots. Inclination of this table in the horizontal plane is plus 15 degrees and minus 30 degrees, and in the vertical plane 30 degrees in either direction.

The semicircular table has peripheral graduations, a circular T-slot with a radius of 6.4 inches, and a saddle length of 11.7 inches. The saddle is mounted on an angle bracket, and has a bearing surface for fitting the headstock and tailstock of 22.1 inches. The distance between centers is 9.9 inches. Inclination in both horizontal and vertical planes is plus or minus 5 degrees. ---------- 101

Boron Carbide-Tipped Abrasive Wheel Dresser

An abrasive wheel dresser with an insert of "Norbide," (a molded boron carbide product of the Norton Co.), is being made by the Robert Marks Co., Providence, R. I. The Norbide insert is 1/4 inch square by 1/2 inch long, and is set in an aluminum handle 5 inches long. The dresser is designed specifically for the free-hand dressing of grinding wheels 10 inches in diameter or less, of any hardness up to M grade.---102



Midget Size Pneumatic Grinder

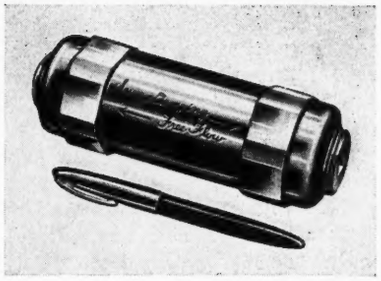
Completely new pneumatic die grinder, designed for precision grinding operations on small dies, castings, and hard to get at spots. The entire tool is 4 5/8 inches long by 1 1/4 inches wide, and weighs 12 ounces. Lever or button type throttle with special collet facilitates holding tool close to work. Arbor run-out held to within 0.0015 inch allows extremely accurate work where pin-point grinding is required. Eight sizes of Erickson precision collets are available for use with this tool, covering a range of shank sizes from 1/64 to 1/4 inch. The rotary vane type air motor is cool running, and develops 26,000 R.P.M. Produced by the Mall Tool Co., Chicago, Ill. 103

Grinding Wheels for Sharpening Carbide Tools

Grinding wheels with a new bond material designed especially for sharpening tungsten-carbide tools by Chicago Wheel & Mfg. Co., Chicago, Ill. The new bond, known as XL, is claimed to give vitrified silicon-carbide grinding wheels definitely superior qualities. Wheels made with this bond are especially recommended for off-hand or precision grinding of carbide milling cutters, broaches, reamers, counterbores, and similar carbide tools. The cutting action of these wheels is said to be both cooler and faster than conventional silicon carbides. They are made in the most popular straight and cup-wheel sizes, and with steel backs. 104

G-E Hook-On Power-Factor Meter

New hook-on meter that permits direct measurement of power factor without cutting conductors or interrupting electrical service. Announced by the General Electric Co., Schenectady, N. Y. This Type AK-3 power-factor meter can be used on any balanced three-phase circuit to give direct readings in circuits with voltages ranging from 100 to 600 volts and currents from 15 to 600 amperes. Designed for use in industrial plants where maintenance of high power factor is an important consideration. 105



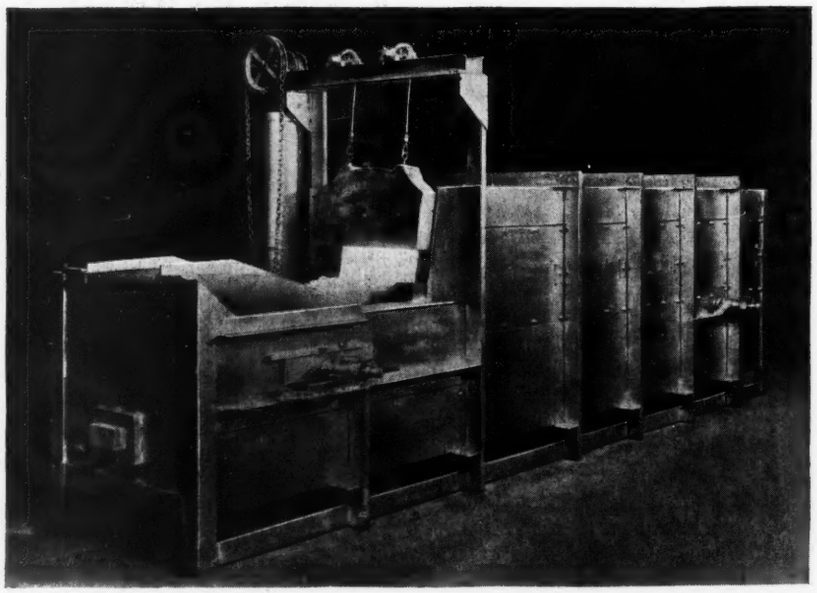
Surge Damping Valve that Prevents Shock in High-Pressure Hydraulic Systems

New surge damping valve said to eliminate excessive shock in high-pressure hydraulic systems. The individual unit is universally adaptable to any hydraulic circuit, and is available in various sizes for a wide range of industrial and aviation applications. The valve adjusts itself automatically to any working pressure, requires only a fraction of a second to act, and does not slow down the cycle time. It prevents damage from vibrations caused by sudden starting or reversing of hydraulic system. Normally closed, it gradually opens when pressure is applied to the inlet side. When the flow is interrupted, the valve quickly resets, ready for the next operation. It requires no manual adjustments and has no external drain. Developed by the Denison Engineering Co., Columbus, Ohio. 106

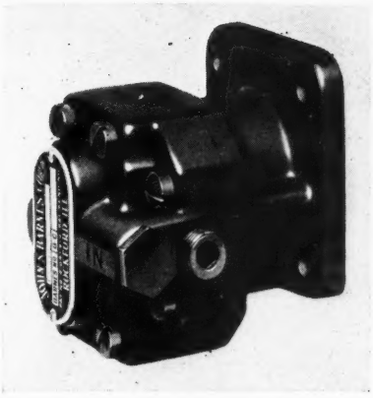
Electric Continuous Heat-Treating Furnace

Electric furnace for heat-treating of wrenches, designed by Bellevue Industrial Furnace Co., Detroit, Mich. The work-carrying belt of this continuous heat-treating furnace is entirely enclosed within the heating zone. With the belt thus enclosed while traveling in both the work-carrying and return directions, there is a minimum of heating loss and lower operating cost. Water or oil can be used as the quenching agent. Production is 800 pounds per hour. 107

(This section continued on page 245)

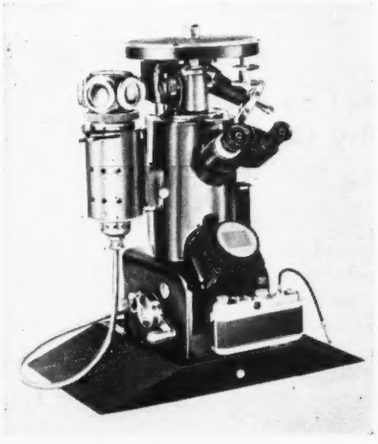


To obtain additional information on equipment described here, use Inquiry Card on page 253.



Barnes High-Pressure Pumps

"Constant-flo" rotary gear pump now available in high-pressure models designed for improved efficiency, brought out by the John S. Barnes Corporation, Rockford, Ill., have the same over-all and mounting dimensions as the low-pressure designs. Standard types of these new high-pressure pumps are built to operate at up to 1000 pounds per square inch continuous duty and 1500 pounds per square inch intermittent duty. Special types for pressures up to 2000 pounds per square inch continuous duty and 3000 pounds per square inch intermittent service can also be supplied. 108

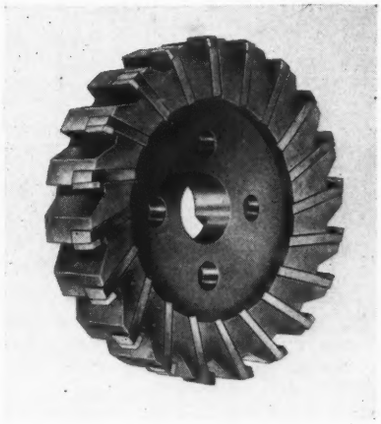


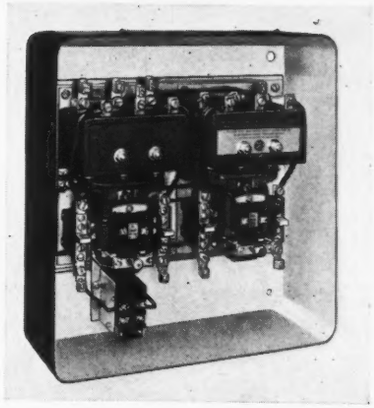
"Metallograph" for Structural Analysis of Metal Samples

"Metallograph" designed to make possible a rapid, low-cost method of analyzing the structure of metal samples and other substances. Includes facilities for photographic reproduction. A large assortment of objective, ccular, and projective lenses are provided. The lenses are coated on all air-glass surfaces and corrected for infinity. This OPL "Metallograph" occupies a table space of less than 12 by 12 inches, and has an over-all height of 18 inches. Controls are provided for fast, positive manipulation of all adjustable elements. Photographs may be taken on 35-millimeter roll film by merely swinging the image from the ground glass to the camera. Product of F. T. Griswold Mfg. Co., Wayne, Pa. 109

Nelco Removable-Insert Face Milling Cutter

Removable-insert face milling cutter of improved design, with fewer parts and a heavier, more rigid body. A positive locking action and heat-treated tool-steel and carbide-tipped blades are new features of this face mill. It is recommended for milling cast iron, steel, aluminum, brass, and bronze, and is said to produce an exceptionally fine finish at high table feeds. Recently announced by the Nelco Tool Co., Manchester, Conn. 110





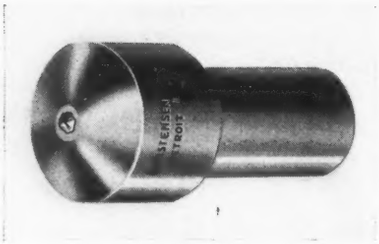
Allen-Bradley Part Winding Starters

New alternating-current part winding starter developed by the Allen-Bradley Co., Milwaukee, Wis., for use with motors that employ two separate parallel windings, star or delta, to obtain increment starting. This "Bulletin 736" starter consists of two A-B across-the-line starters and a pneumatic timing mechanism mounted below one starter and operated by the starter's solenoid plunger. Pressing the start button immediately closes the first starter, which energizes one of the two parallel windings. Meanwhile, the timer is in operation, and after a few seconds, energizes the second starter. With both starters closed, full line current is supplied to the motor through both windings, each using 50 per cent of the total current drawn. It is said that use of part winding starting eliminates objectionable current surges. 111

Steam Gun for Heavy-Duty Cleaning

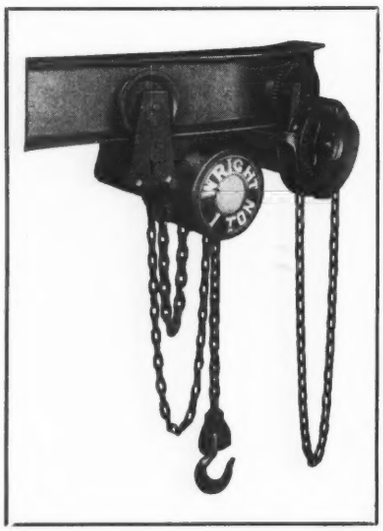
"Solution-Lifting" steam gun for use in heavy-duty steam cleaning operations where range of operating pressures (at boiler end of hose while gun is in use) is 50 to 100 pounds per square inch with minimum recommended boiler rating of 25 H.P. With this gun, a steam-detergent spray is automatically lifted 12 feet above the working level to provide thorough cleaning of large equipment and other surfaces. The gun, known as Model 502, is 7 1/2 feet long and weighs 15 3/4 pounds. It is an addition to the line of cleaning equipment manufactured by Oakite Products, Inc., New York City. 112

To obtain additional information on equipment described here, use Inquiry Card on page 253.



Christensen Single-Point Diamond Wheel-Dressing Tool

Single-point diamond wheel-dressing tool made by the Christensen Diamond Tool Co., Detroit, Mich. Manufactured in a full range of sizes for all grits of grinding wheels. The "C metal" mounting holds the diamond securely, regardless of severe vibration or intense alternations of heating and cooling caused by frequent wheel applications. Each single-point tool contains one whole natural diamond, ranging from fractional to 3 carats in size, for use on any straight-face or form-wheel dressing operation. 113

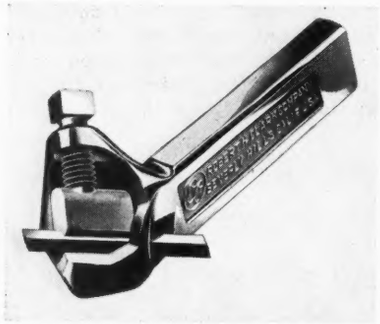


Wright "Safeway Army" Type Trolley Hoist

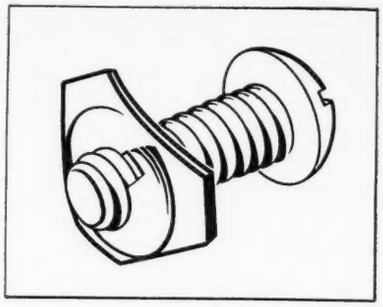
"Safeway Army" type trolley hoist, made in capacities from 1/2 ton to 3 tons. Available with a special load bar and either a pair of two-wheel plain trolleys or one plain and one geared two-wheel trolleys. The plain trolley assembly is adjustable for a wide range of beam sizes, and can be changed from plain to geared type in a few minutes. The geared trolley is equipped with thrust rollers mounted to insure proper alignment of the assembly, whether on a straight or a curved track. These hoists are designed for service where a close headroom assembly is required. Announced by Wright Hoist Division of American Chain & Cable Co., Inc., York, Pa. 114

Clark Adjustable Tool-Holder

Adjustable tool-holder with vise grip jaw designed to exert equal pressure on the tool bit over the full length of the cutter channel and thus permit faster feeds and deeper cuts. The adjustable screw-operated vise-grip jaw also has the advantage of permitting the use of



several sizes of tool bits, as well as bits that are over size, square, round, and out of round. These holders are drop-forged, heat-treated, and hardened. They are available in both standard 15-degree and parallel channel types for carbide bits, threading tools, and boring bars. The vise-grip jaw rigidly clamps short tool bits and stub ends, as well as narrow tool bits. Placed on the market by the Robert H. Clark Co., Beverly Hills, Calif. 115



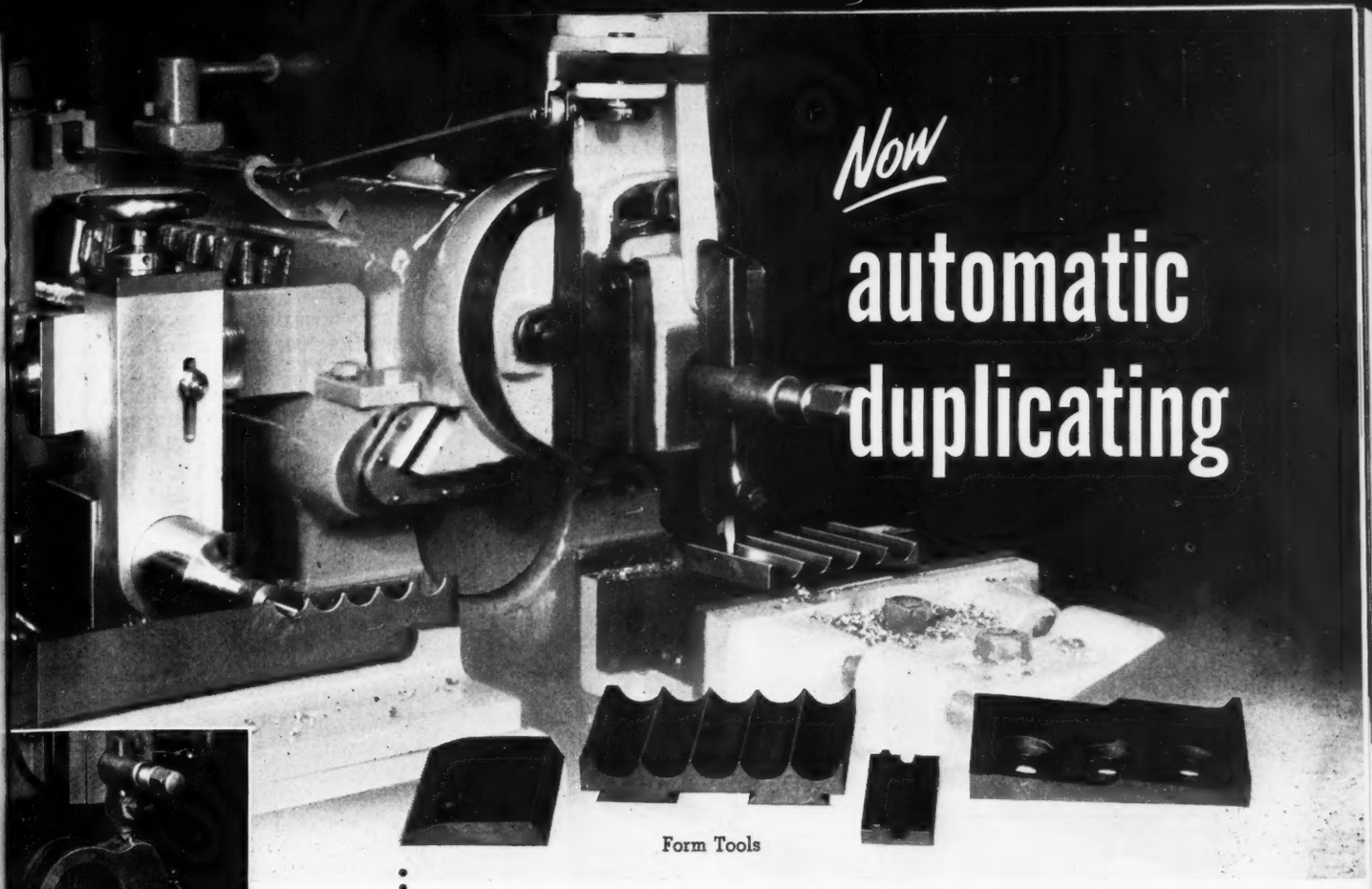
New "Truarc" Retainer Designed to Act as Self-Locking Nut

New type of retainer designed to act as a self-locking nut on threaded shafts. Made by Waldes Kohinoor, Inc., Long Island City, N. Y., and designated "Truarc" Series 5300. The new triangular-shaped retaining nut has a drawn helical segment with a tapered inner edge that forms a single thread conforming with American standards. When screwed on a threaded shaft, the dished triangular body flattens under torque and produces an equal load distribution against the part being held. Separate washers are unnecessary. Under spring tension, the threaded helical segment of the nut engages the screw thread to its full depth for about five-sixths of the circumference of the screw, so that the nut will remain secure under impact and vibration. 116

Device Developed for Use in Continuous Sampling Method of Quality Control

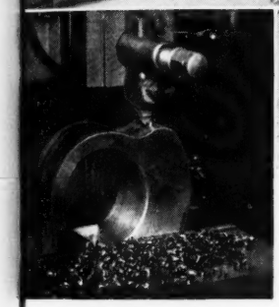
"Continuous sampling monitor" — an electrical device that automatically records the data required for applying the sampling method of quality control. Developed by the General Electric Co., Schenectady, N. Y., to eliminate the complexity of paperwork inherent in the continuous sampling methods of quality control. The monitor is contained in a small cabinet, approximately 12 by 6 by 6 inches. The control box, located so that the inspector can easily operate the push-buttons and read the indicator lights, is 4 by 4 by 2 inches, and is connected to the monitor by a multi-conductor cable. The monitor requires 110 volts, and has a maximum counting speed of 500 units per minute. 117

To obtain additional information on equipment described here, use Inquiry Card on page 253.



Now automatic duplicating

Form Tools



plicating a cam

es from templates

...ON A CINCINNATI SHAPER

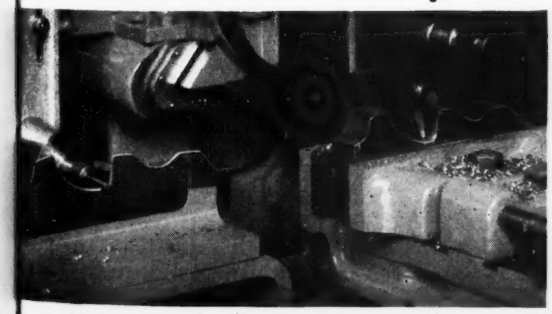
You can duplicate parts on a versatile Cincinnati Shaper with a single point tool, using actual parts or simple sheet metal templates—at new speeds and new low costs.

This automatic duplicating device has a wide application in the tool and die field—and also produces a very large variety of parts in the general shaping field. We illustrate some of these shapes accurately produced at low costs with single point tools.

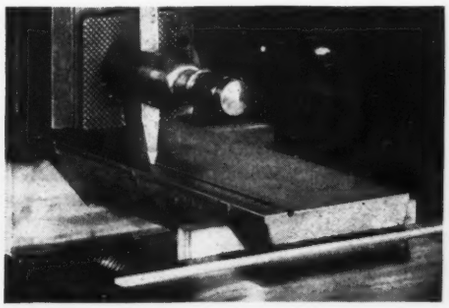
Cincinnati Shapers equipped with this device are instantly reconverted to standard shaping operations and retain all their versatility.

A Cincinnati Shaper with automatic duplicating device can save you time and money in your shop.

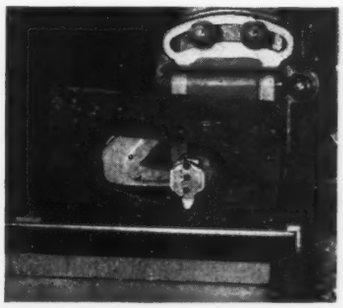
Write for Automatic Contour Duplicating Bulletin DN-1.



cing 90° shoulders



Interchangeable molds



Duplicating internal contours

THE CINCINNATI SHAPER CO.

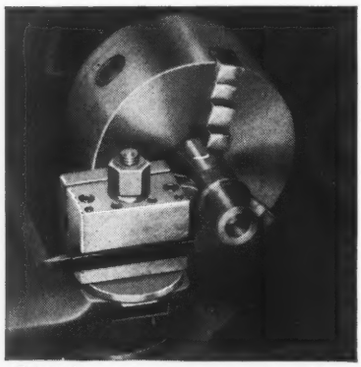
CINCINNATI 25, OHIO, U.S.A.

SHAPERS · SHEARS · BRAKES

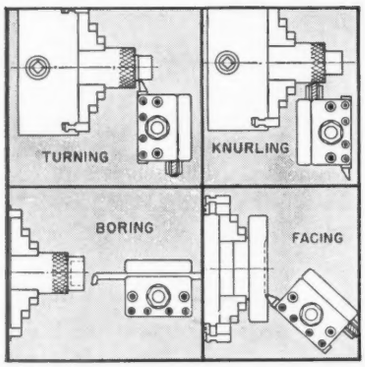
CINCINNATI

New South Bend Lathe Tool-Holder

A new tool-holder (upper view) of the universal type, brought out by the South Bend Lathe Works, South Bend, Ind. This tool-holder, called the "10 in 1," while designed for use on South Bend lathes, can be adapted for use on some other makes of lathes. It is constructed of heat-treated steel, and has a screw adjustment for tool height. Once the holder is adjusted, tools of the same type can be changed without disturbing the adjustment. Equipment includes a self-aligning knurling head and a pair of medium diamond knurls. Coarse and fine diamond knurls, and coarse, medium, and fine straight-pattern knurls are available. Boring tools, cutting-off blades, and a set of four ground cutter bits can be supplied for boring, cutting-off, turning, facing, and threading operations, set-ups for different operations being shown in the lower view. 118



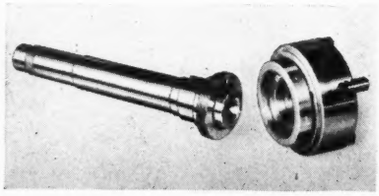
Patented



Patented

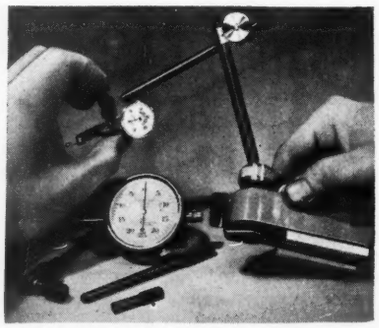
Wade Improved Spindle Nose for Lathe

"Thread-Lock" spindle nose developed by the Wade Tool Co., Waltham, Mass., for the company's No. 8A toolmaker's precision lathe. The particular advantage of this patented spindle nose is that the chuck can be easily located and locked in place by the half turn of a locking ring. The spindle nose is designed to accurately secure chucks, faceplates, etc., to the spindle. 119



Indicator Holder with Magnetic Base

Portable magnetic-base holder for indicators. Attaches securely to flat or curved surface with 100-pound pull. Finger-tip release permits instant removal or positioning without jarring indicator. Accessories provide for mounting different types of indicators. Made by Enco Mfg. Co., Chicago, Ill. 120



First International Metallurgical Congress

Metal resources, upon which rest the security and freedom of the world, will be discussed by metal scientists and engineers from the free nations of Europe, Africa, and Asia, as well as from North and South America, at a World Metallurgical Congress, to be held in Detroit, Mich., from October 15 through 19.

More than 500 delegates from upward of twenty freedom loving countries will assemble to exchange ideas and join with thousands of American metallurgists to participate in the first international metallurgical meeting of this kind. The meeting is sponsored by the American Society for Metals, and will be held concurrently with the thirty-third annual National Metal Congress and Exposition.

It is stated that the full support of the Economic Cooperation Administration has been extended to this enterprise, and a technical assistance program, providing for visits of delegations of metal scientists, has been established by the E.C.A. The foreign "conferees" will spend approximately five weeks in the United States, during four of which they will participate in a series of study tours to industrial, government, and educational institutions.

Dr. Zay Jeffries, retired vice-president of the General Electric Co., and a past president of the American Society for Metals, has been appointed director general of the World Metallurgical Congress.

Further information can be obtained from William H. Eisenman, secretary of the American Society for Metals, 7301 Euclid Ave., Cleveland, Ohio.

* * *

New Electronic Research and Engineering Center

The establishment of a National Bureau of Standards laboratory center at Corona, Calif., to be devoted to various phases of electronic research, development, and engineering has been announced by Dr. E. U. Condon, director of the National Bureau of Standards. The new Corona Laboratories will be primarily concerned with technical problems of importance to the Department of Defense.

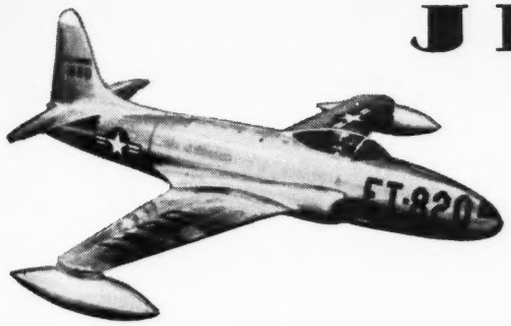
Oxy-Argon Mixture Used as Shield in Welding

A new principle that increases the speed of inert-gas metal-arc welding of stainless and carbon steels has been announced by The Linde Air Products Co. Any oxy-argon mixture is used as a shielding atmosphere, which permits welding at lower current densities, enables larger diameter rods to be used for a given welding current, and makes it practicable to weld thinner materials.

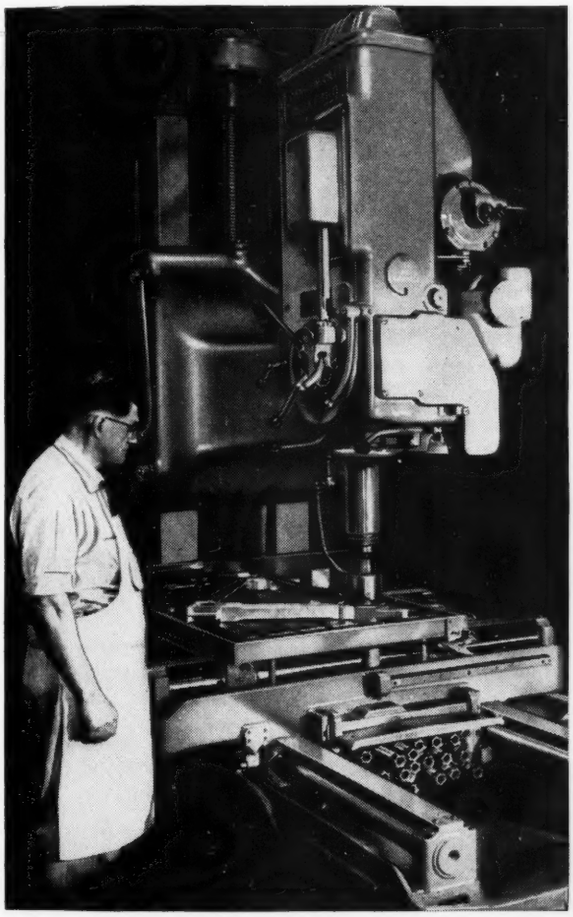
Dr. Jess H. Davis Named President of Stevens Institute

Dr. Jess Harrison Davis, president of Clarkson College of Technology, Potsdam, N. Y., has been elected president of Stevens Institute of Technology, Hoboken, N.J., succeeding Dr. Harvey Nathaniel Davis. The new president, who is the fourth in the eighty-one-year history of the college, will assume his duties September 1, 1951.

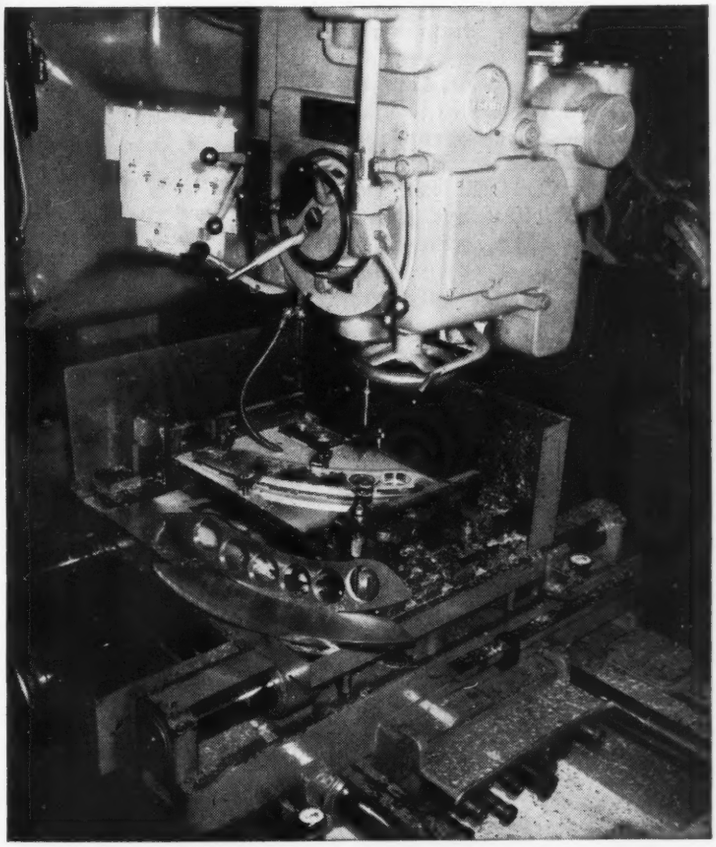
To obtain additional information on equipment described here, use Inquiry Card on page 253.



JIGLESS ACCURATE DRILLING



Precision production work without the use of jigs, at Lockheed, is now being accomplished on the Cincinnati Bickford PRECISION Drilling Machine, equipped with a Bullard Man-Au-Trol Spacer. A variety of production jobs, such as cutting holes approximately 3" in diameter, through curved plates of magnesium about 5/8" thick, are now being economically produced without the use of jigs. First, a 5/16" hole is used as a pilot hole for a fly cutter. The total tolerance on the diameter of the accurately located holes is .001". According to Lockheed, "Fast, repetitive drilling is handled without the use and expense of jigs — heavy parts including castings are automatically positioned under the jig boring type spindle — parts handling is minimized — storage and maintenance of drill jigs are eliminated."



Where repeated accuracy of hole spacing, drilling, reaming and tapping is to be economically facilitated, the combination of the SUPER SERVICE PRECISION Drilling Machine and the Bullard 30" x 20" Spacer is hard to beat. Not only is production speeded — there is no waiting for jigs to be made. You can get into production of vitally needed parts right away.

Ask the Cincinnati Bickford Tool Company, of Cincinnati 9, Ohio, or the Bullard Company, of Bridgeport 2, Connecticut, for further information about this natural combination.

THE CINCINNATI BICKFORD TOOL CO. **Cincinnati 9. Ohio U.S.A.**

Elmes Engineering Division Celebrates One-Hundredth Anniversary

THIS year marks the one-hundredth anniversary of the Elmes Engineering organization—now the Elmes Engineering Division of American Steel Foundries—which operates the modern plant shown below, located at 1150 Tennessee Ave., Cincinnati, Ohio. The original business was founded at Bath, Me., in 1851 by Carleton D. Elmes, and occupied the small building illustrated in the sketch. Job work, principally for the marine industry, was the main activity. The business expanded rapidly, and in 1861 was moved to Chicago, where Charles F. Elmes, son of the founder, joined the enterprise. Later, the father and son organized a co-partnership under the name Elmes & Son.

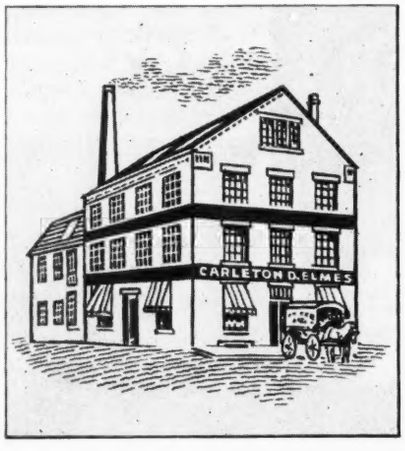
After the death of the founder in 1877, the business was conducted under the name of Charles F. Elmes until 1895. Activities then included the building of steam engines for power plants and the building and maintenance of pumping equipment for the Chicago Water Works and engines of the Chicago Fire Department. Steam engines were built and maintained for the Commonwealth Edison Co. and the Chicago Street Railways. Continuous expansion of the business made it necessary to obtain more adequate quarters, and in 1893, a much larger plant was erected in Chicago to meet this need.

In response to an ever growing demand, the concern was concentrating during the later years of the Nineteenth Century on the building of hydraulic presses and high-pressure pumping equipment. In 1895, a corporation was formed that was known as the Charles F. Elmes Engineering Works, with Charles F. Elmes as president.

Upon the latter's death in 1904, the organization was conducted by his sons, Charles W. Elmes and Carleton L. Elmes. At this time, the concern pioneered in the development of many types of hydraulic equipment, including presses for producing linseed oil, belting presses, vulcanizing presses, filter presses, and, prominent in the field today, metal-forming, plastic-molding, wheel, and lead-extrusion presses.

In 1943, the concern was purchased by American Steel Foundries, and Charles F. Elmes, great grandson of the founder, was appointed general manager of the Elmes Engineering Division. In 1949, the concern moved to its present home in Cincinnati.

Typical of the advanced production facilities in this plant is an assembly pit, 10 feet deep, especially designed for use in erecting large hydraulic presses. Men can work on top of such presses at floor level without climbing up and down ladders. Movable pit covers permit the erection of presses of normal height on top of the pit, thus providing double-duty facilities. The products of the concern today include a complete line of hydraulic presses and equipment, both standard and custom built, as well as pumps, accumulators, valves, and accessories.



Sketch of the building in which Carleton D. Elmes one hundred years ago started the business that has become the Elmes Engineering Division of American Steel Foundries, and view of the present modern plant